Effects of Forest Herbicides on Some Important Wildlife Forage Species

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September 1989

ECONOMIC & REGIONAL DEVELOPMENT AGREEMENT

Canada

BC

90-01253/

Partial funding for this research project and the cost of printing this publication were provided by the Canada/British Columbia Forest Resource Development Agreement - a five year (1985-90) $300 million program cost-shared equally by the federal and provincial governments.

Canadian Cataloguing in Publication Data

Balfour, Patty M.
Effects of forest herbicides on some important wildlife forage species

(FRDA report, ISSN 0835-0752 ; 020)

Issued under Forest Resource Development Agreement.
Co-published by B.C. Ministry of Forests.
"Canada/BC Economic & Regional Development Agreement."
Bibliography: p.
ISBN 0-7718-8622-5

1. Herbicides - Canada, Western. 2. Herbicides - Northwest, Pacific. 3. Forage plants - Canada, Western. 4. Forage plants - Northwest, Pacific. 5. Plants, Effect of herbicides on - Canada, Western. 6. Plants, Effect of herbicides on - Northwest, Pacific. I. Canada. Forestry Canada. II. British Columbia. Ministry of Forests. III. Canada-British Columbia Forest Resource Development Agreement. IV. Canada/BC Economic & Regional Development Agreement. V. Title. VI. Series.

SB951.4.B34 1989 633.2'08954 C88-092045-9

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Province of British Columbia

This is a joint publication of the Canadian Forestry Service and the British Columbia Ministry of Forests.

Produced and distributed by the Ministry of Forests, Research Branch.

For additional copies and/or further information about the Canada-British Columbia Forest Resource Development Agreement, contact:

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ACKNOWLEDGEMENTS

Throughout this project I have consulted several Ministry of Environment staff members. I would like to thank the following people for their assistance and/or editorial reviews: Ted Lea (Victoria), Sylvia von Schuckmann (Queen Charlotte City), Julia Beatty (Victoria), Andrew Harcombe (Victoria), Fred Harper (Fort St. John), Marty Beets (Williams Lake), and Gordon McKinnon (Penticton). I would also like to thank John Henigman and Jacob Otchere-Boateng (Ministry of Forests, Victoria) and John Pollack (Ministry of Forests, Prince Rupert) for their review comments and clarifications of British Columbia Forest Service herbicide use and research. I am grateful to Denise Bijold (British Columbia Systems Corporation, Victoria) for her assistance in implementing the computer data entry system.

Especially, I would like to acknowledge Terje Vold (Ministry of Environment, Victoria) for his key role in monitoring this project as well as providing continuous support, patient editing and valuable advice. Also I would like to thank both the Ministry of Forests, who provided the Wildlife Branch with funding support, and Roberta Parish for her interest and editorial assistance. Finally I would like to thank FRDA for publishing the report.

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1 INTRODUCTION

The purpose of this report is to consolidate information on the effect of forest herbicides on important wildlife forage species. This was accomplished by reviewing herbicide trial results from British Columbia, Alberta, Saskatchewan, Washington, Oregon, and Idaho. No original research was done. From the approximately 1300 entries analyzed, summary results were tabulated on the basis of chemical type, and rate and season of application. It is hoped that the identification of both the "demonstrated" and "unknown" effects will assist the evaluation of herbicide prescriptions and the direction of further studies.

There are more variables affecting plant sensitivity and herbicide efficacy than can be accounted for in a two-dimensional table. For this reason, each entry has been referenced and should be consulted for further information about the individual trials.[1] As well, the table entries represent averaged results of work of varying intensities and should be approached accordingly. The accompanying text supplements the tables by highlighting trends and exceptional entries. To assist their evaluation of each entry, users should refer to Tables 1–6 in Appendix 1, which show the amount of data and associated range of data for all the report's entries. Data collection was completed by December 1986.

[1] Balfour, P.M. 1987. Effects of forest herbicides on wildlife forage species in British Columbia. Appendices. B.C. Min. Environ. Parks., Wildlife Branch. Unpublished report.

2 METHODOLOGY

2.1 Literature Review

The review covered literature from British Columbia, Alberta, Saskatchewan, Oregon, Washington, and Idaho. To qualify for data entry, the research had to specify type of chemical, rate, and season of application. However, generalized findings, ineligible for data analysis, were used to supplement the text. The publication by Boyd *et al.* (1985) was the primary source of information; approximately half the data analyzed are from this summary of herbicide trials performed in the inland Northwest of Washington, Oregon, and Idaho. With the Conard and Emmingham (1983, 1984a–d) trials from Oregon and Washington, the United States trials account for approximately 60% of the total considered in this analysis.

Various research projects performed by the British Columbia Ministry of Forests (including some silvicultural trials) provided most of the British Columbia information; most was limited to the Prince Rupert Forest Region (Gilmour and Ackerman 1983; Ackerman and Wyeth 1985; D'Anjou 1985; Newhouse and Geisler[2]). The Expert Committee on Weeds (1985) was the source of the remaining western Canada information. Therefore, although the basis of the analysis might be questioned in its "provincial" representativeness, it does identify the location and type of research currently available. Data from surrounding areas were included to make up for the incomplete British Columbia data set.

Virtually all research reviewed was forestry oriented, reporting the degree of vegetation control, rather than the wildlife habitat consequences of decreased forage production.

2.2 Wildlife Forage Species

The ungulate forage species (Tables 1–10 in Section 3) are those rated by Blower (1982) as being of high and medium importance (Appendix 2). The publication, "Food Habits of Wild Ungulates in British Columbia" (Singleton 1976), was also consulted and any additional high or medium-high species, summer or winter, were added if not already on Blower's list. Finally, to achieve a regional perspective, regional wildlife and habitat biologists provided comments on the species list.

A list of interior forage species for grizzly bears (Table 11, Section 3) was compiled from the following references: McLellan (1981), Hamer and Herrero (1983), and Simpson *et al.*[3] A list of coastal forage species for grizzly bears (shown on Table 12, Section 3) was compiled from Archibald *et al.* (1985).

2.3 Herbicide Treatments

2.3.1 Chemicals

This report focuses on herbicides currently used in British Columbia forestry. Glyphosate accounts for approximately 80% of this use (Walmsley *et al.* 1986). Hexazinone, the most recently introduced herbicide, is presently being analyzed in much of the research. Currently, liquid hexazinone has only temporary registration and granular hexazinone is not registered. Both 2,4-D amine and 2,4-D ester were used in British Columbia as early as 1956. More than 95% of the 2,4-D applied in the province in 1985 was of the amine formulation (J. Henigman, pers. comm., B.C. Ministry of Forests). Triclopyr ester is used only for research purposes at this time. The chemical asulam has not been included in this study because of its limited and specific use for bracken control (J. Henigman, pers. comm., B.C. Ministry of Forests).

2.3.2 Rates

To determine what rates of herbicide application might satisfy both forestry and wildlife forage objectives, the effects of different rates on vegetation were examined.

The rates used are arranged by method of application: 1) individual (herbicide applied individually to target species); 2) broadcast, with less than 50% of the current allowable maximum; and 3) broadcast, with

[2] Newhouse, F. and M. Geisler. 1986. Herbicide efficacy: results of the fall '85 assessments. B.C. Min. For. Lands, Prince Rupert Forest Region. Unpublished field observations.

[3] Simpson, K., K. Hebert, and G. Woods. 1985. Habitats and management of the Grizzly Bear (*Ursus arctos* L.) in the Columbia Mountains of British Columbia. B.C. Min. Environ. Parks, Wildlife Branch. Unpublished report.

between 50 and 100% of the current allowable maximum. An example of "individual" application is hack and squirt treatments, in which the chemical is used at various strengths and the rate per hectare is determined by stand density. Grid pattern applications of liquid hexazinone were also singled out in the "individual" column, to separate this method from the broadcast treatments. Data from any trial applying rates above the federal registration maximum are excluded from the summary tabulations. They are, however, retained in the data base and marked with an asterisk. Also, if any additives were used, the entry was excluded from the data summary to minimize the number of variables. However, ester formulations of 2,4-D and triclopyr were included regardless of whether the carrier was water or oil.

2.3.3 Seasons

Because of localized environmental and climatic variations, a phenological description of season is more appropriate for herbicide trial data than a calendar description. The phenological stages used in this report are after Boyd *et al.*(1985) (see Appendix 3). However, since the term "foliar" can be used to describe both a timing of application as well as a method of application, the written text will use "spring" and "summer" for early foliar and late foliar applications, respectively. For data compilation, an attempt was made to assign all data into the following framework of "season".

Code	Phenological stage	Description
D	Dormant or budbreak	Late winter or early spring at beginning of spring flush of growth. Buds on conifers swelling or bursting, or new leaves unfolding. —November–March —winter
EF	Early Foliar	Period of active growth; approx. ¾ of new leaves on shrubs full size. —April–June —spring
LF	Late Foliar	During midsummer, usually mid-July to early August, after cessation of growth on conifers and shrubs. All leaves full size and hardened. New terminal buds well developed on conifers. —July —summer
LS	Late Summer	—Usually late August to early September, long after cessation of spring flush of growth.
F	Fall	—September–October —fall

2.3.4 Results

Each entry in the computerized data base records results in the working language of the researchers. Consequently, the data base includes percent defoliation, percent topkill, percent dead, and written descriptions. To summarize the data, all the findings were treated as equal percent figures. Where researchers recorded more than one result for each treatment, an average was used. It is important to note that this review defined "year one" data as observations made within the same calendar year of application (after Boyd *et al.* 1985); not all researchers use this definition. For instance, if glyphosate is applied in the fall, assessments made in the following year are often termed "year one" referring to observations made one "growing season" after application (J. Pollack, B.C. Ministry of Forests, Prince Rupert, pers. comm.). All the entries in a particular category (e.g., Glyphosate/EF/>1.1<2.2 kilograms of active ingredient per hectare [kg ai/ha]) were averaged and the table descriptions in section 3 were attributed to these general percentages.

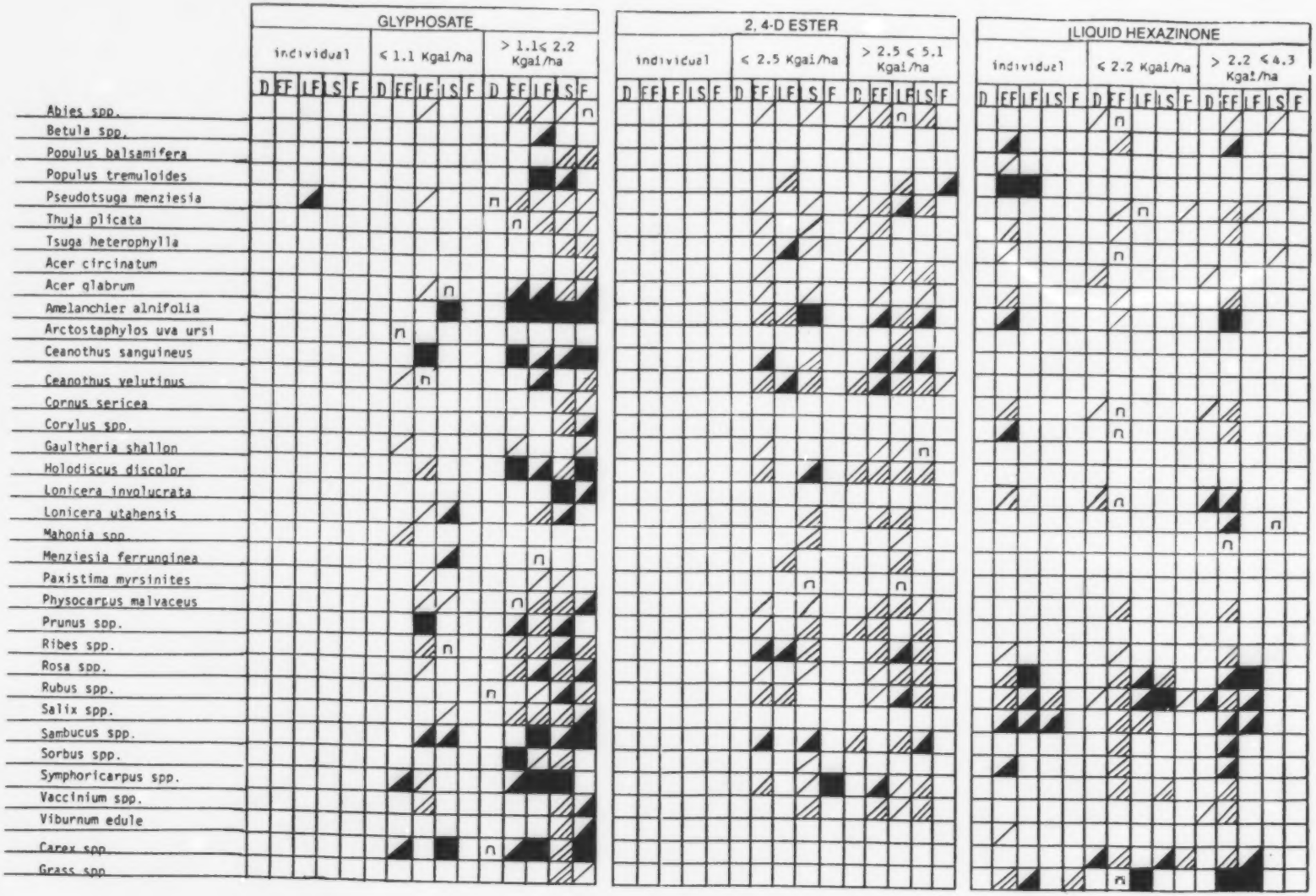
3 SUMMARY TABLES

Key to categories of impact of herbicides on forage species used in Tables 1–12

no data	
No effects noted	n
<25% light	
>25% <60% moderate	
>60% <90% severe	
>90% very severe	

The rate range tables (Appendix 1) provide the maximum range over which results were noted.

TABLE 1. Summary table of forage species with data



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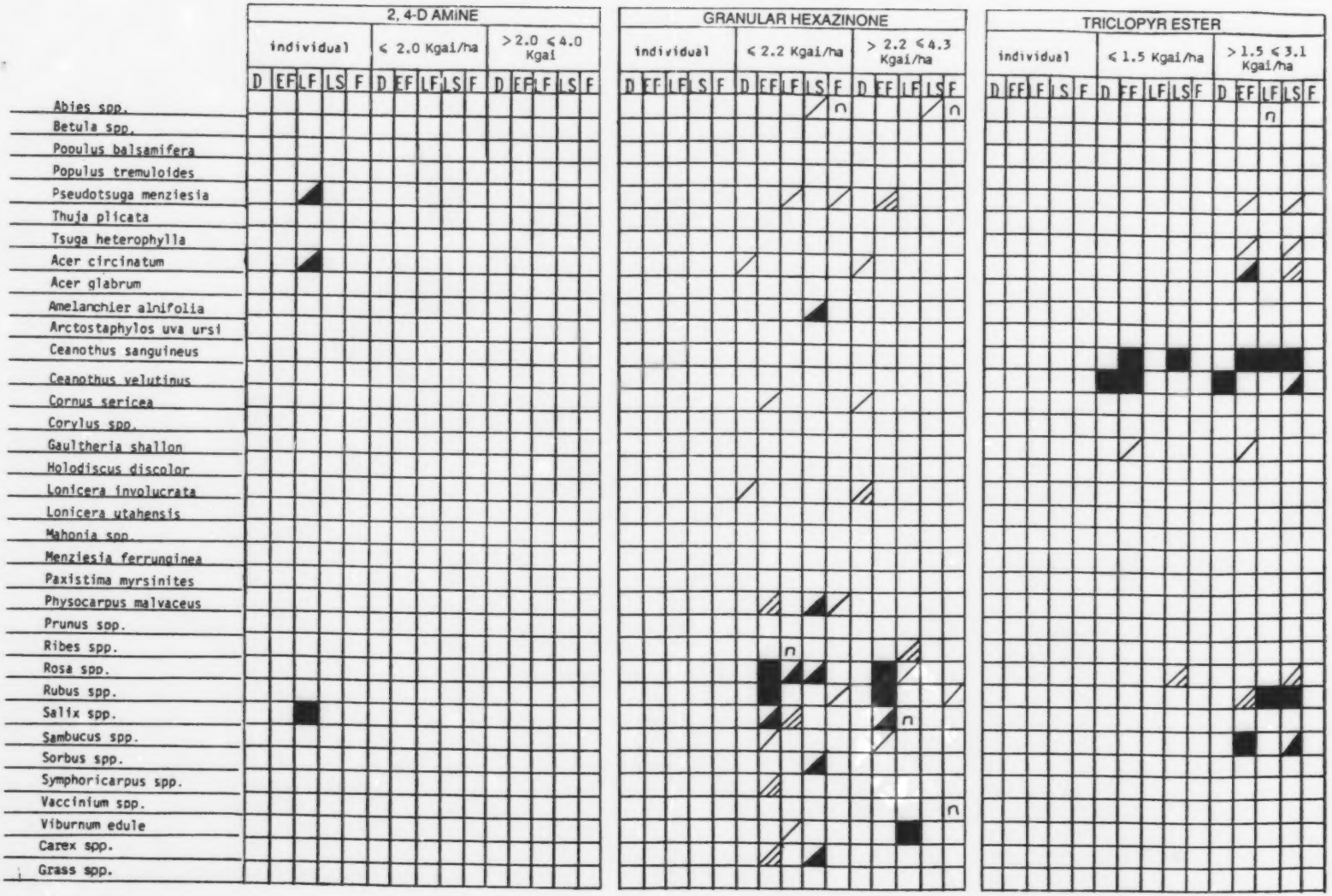
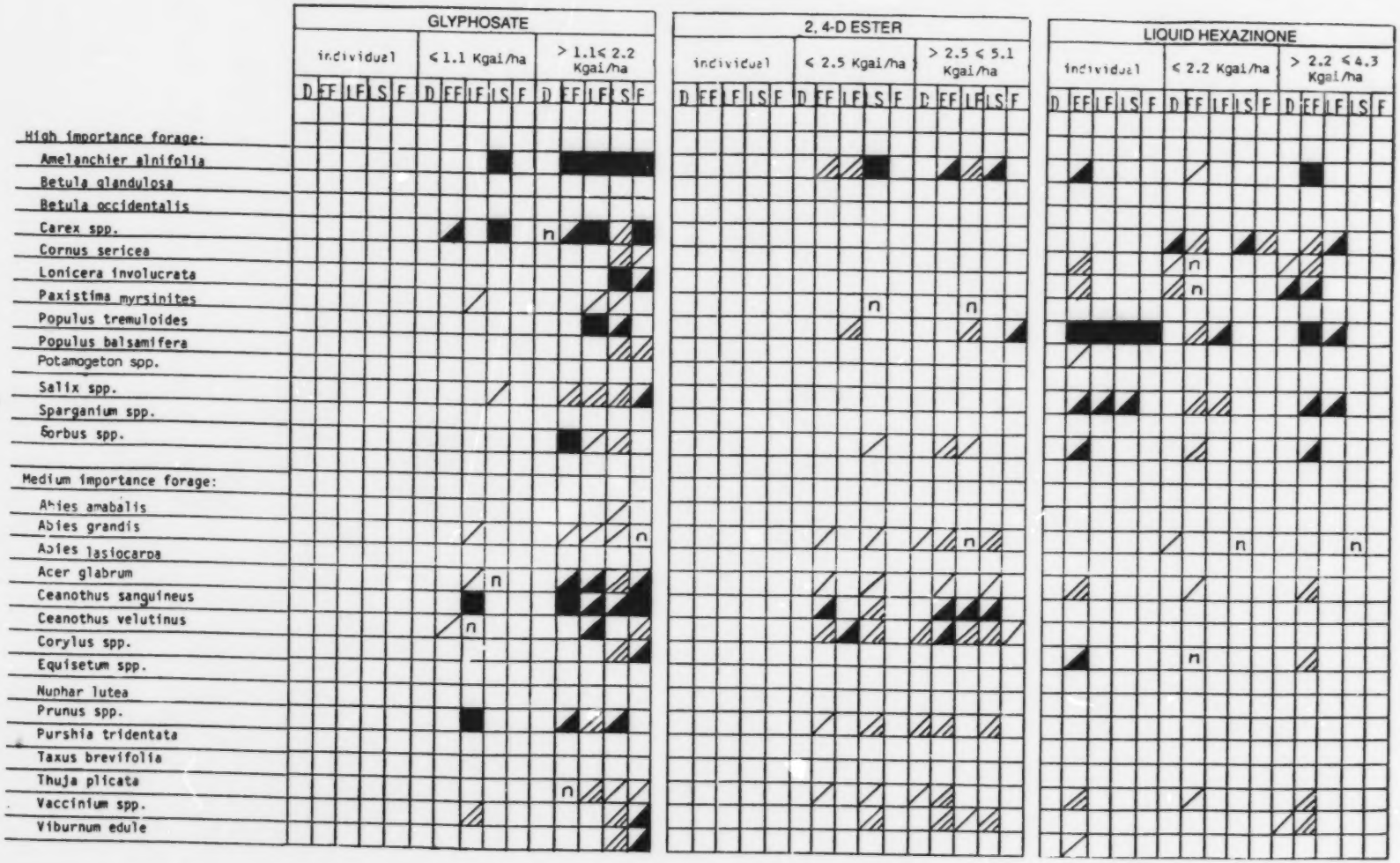


TABLE 2. Moose forage species data summary



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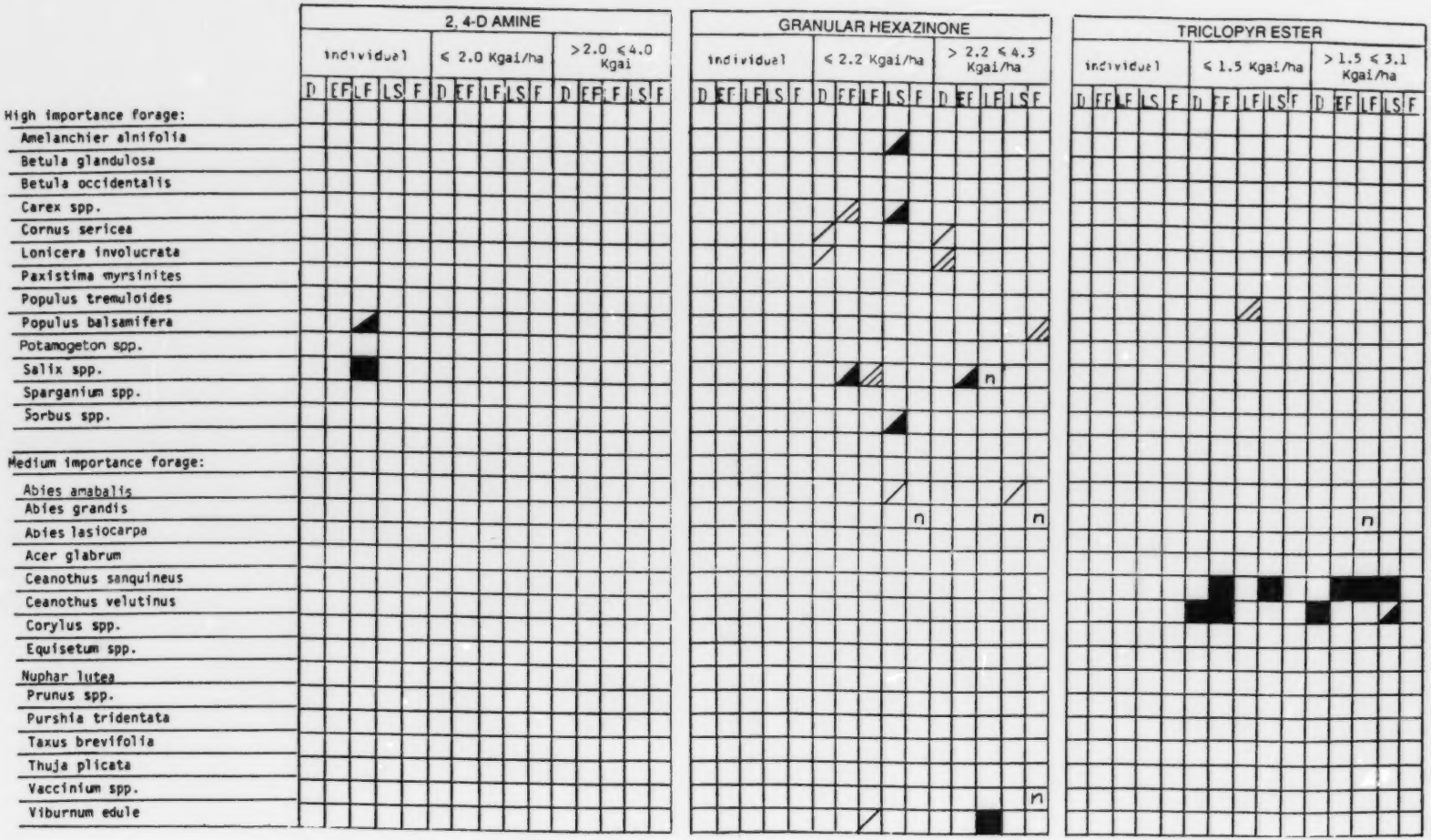


TABLE 3. Rocky Mountain Elk forage species data summary

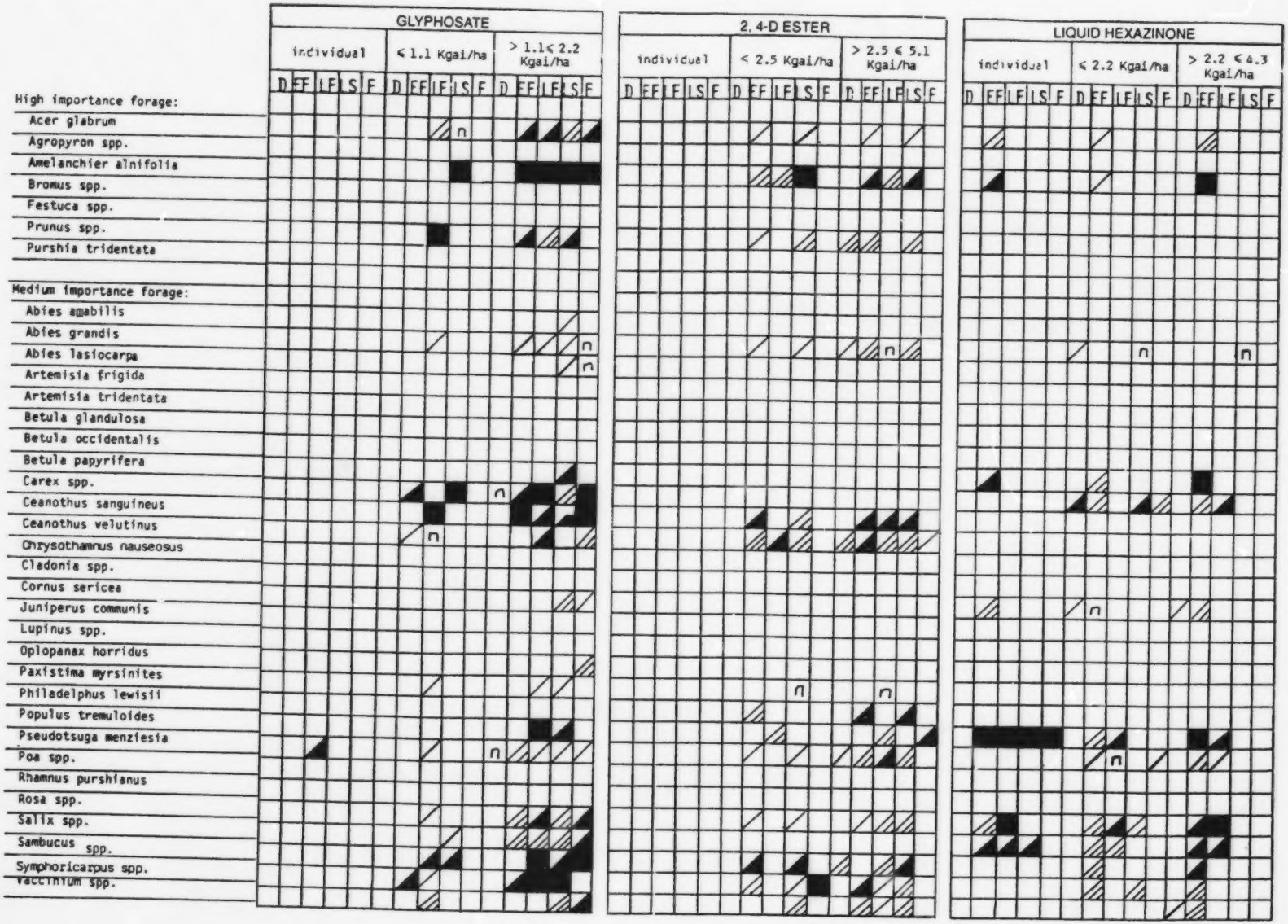


TABLE 3 — *Continued*

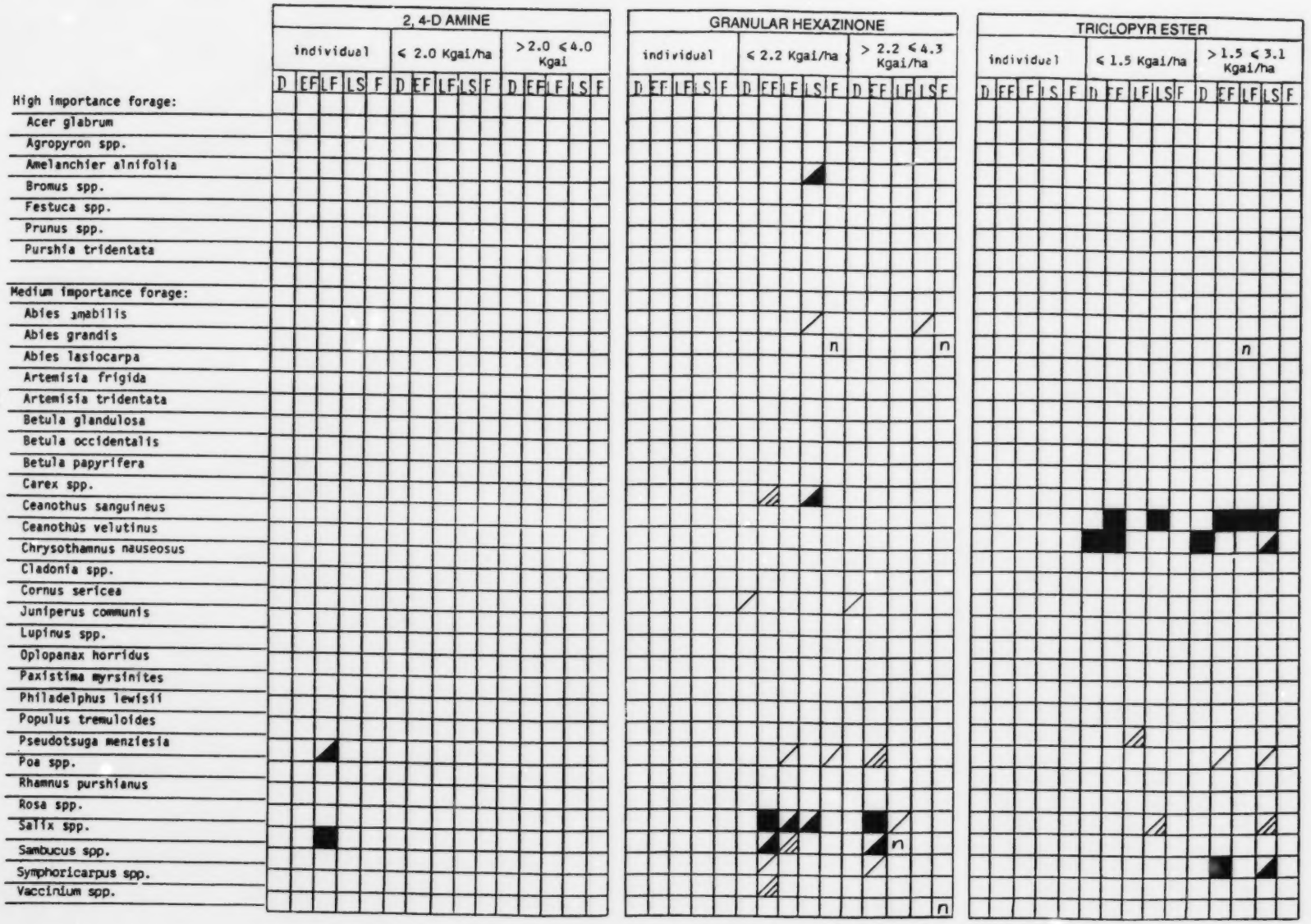


TABLE 4. Roosevelt Elk forage species data summary

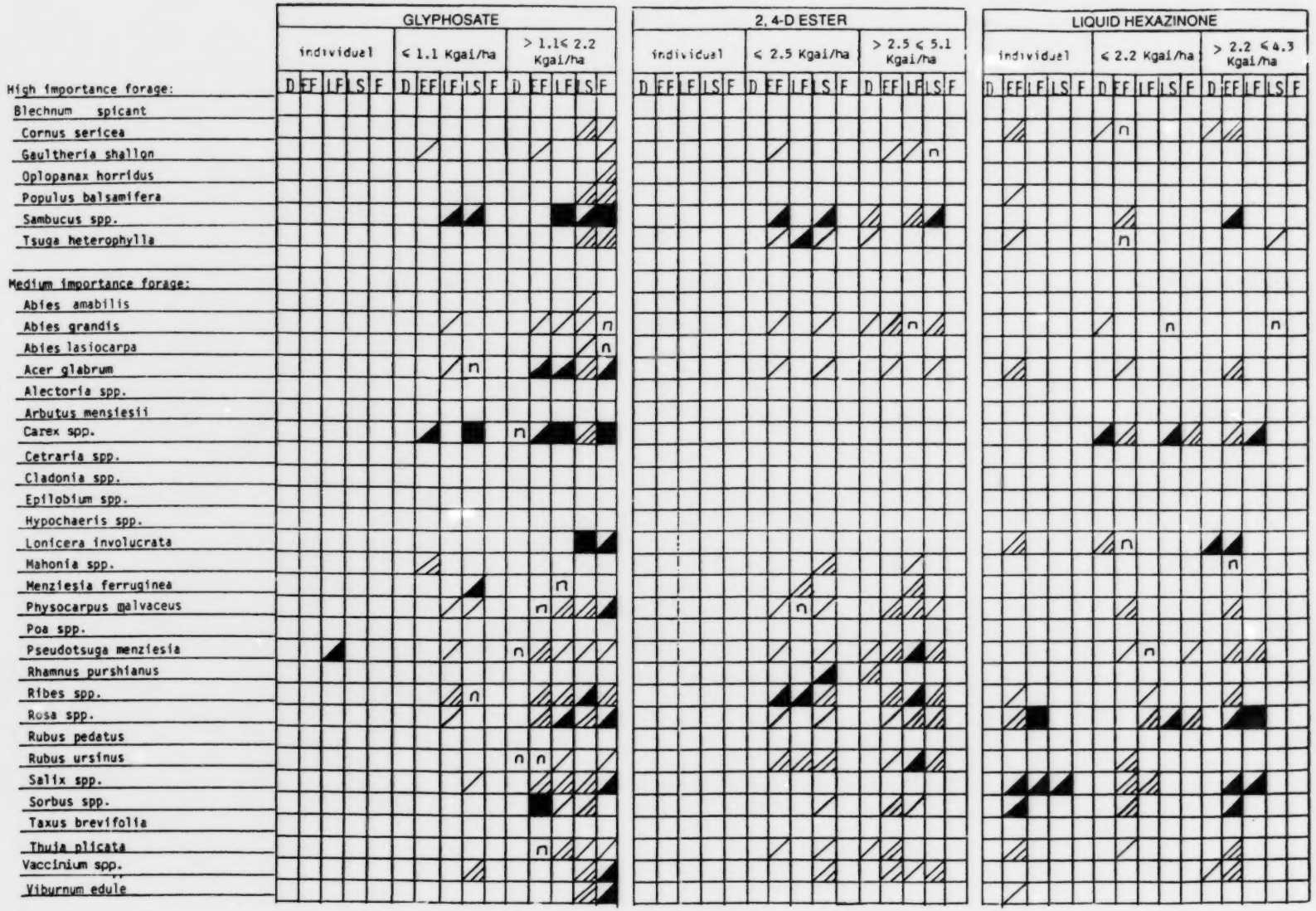


TABLE 4 — *Continued*

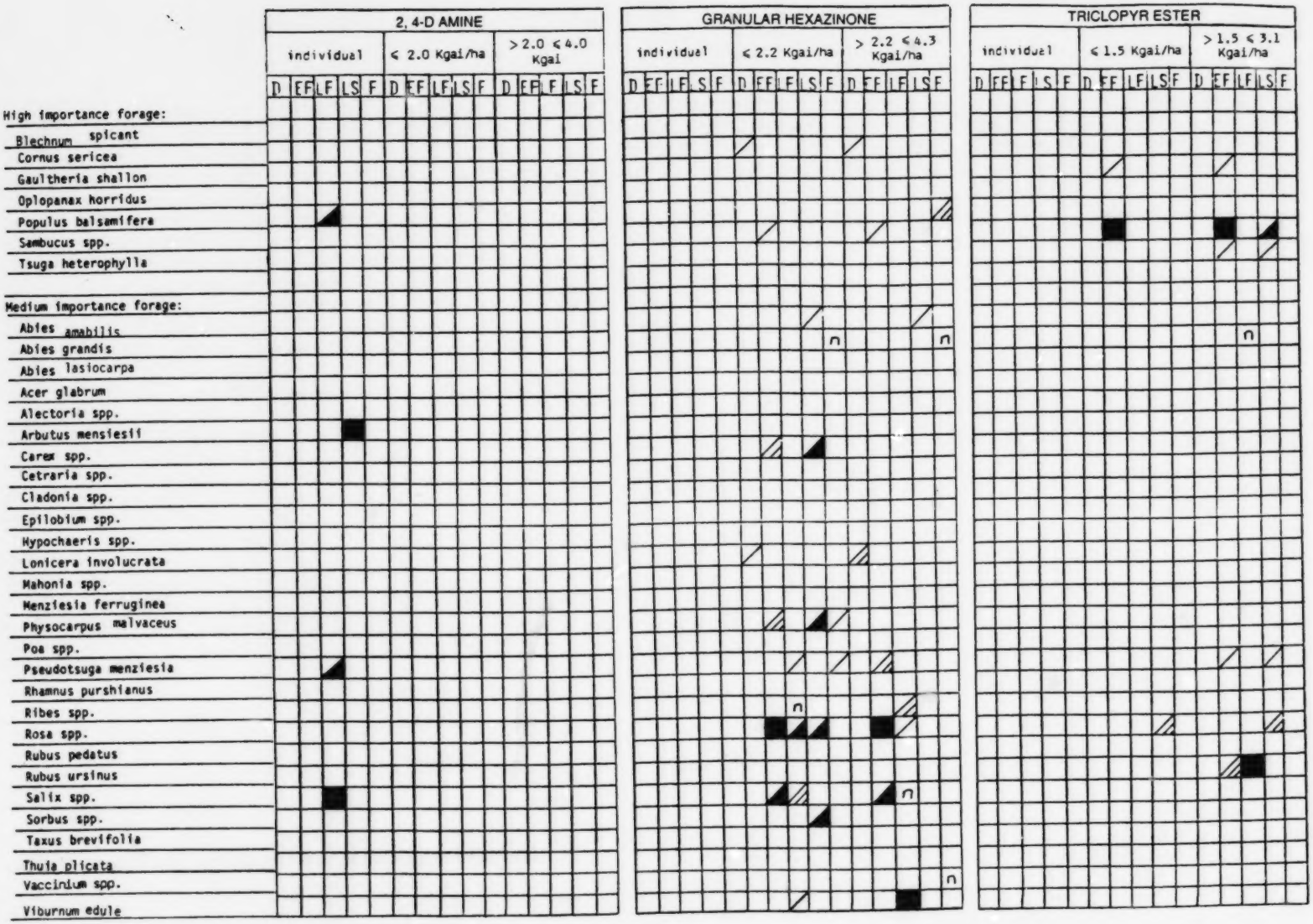


TABLE 5. Bighorn Sheep forage species data summary

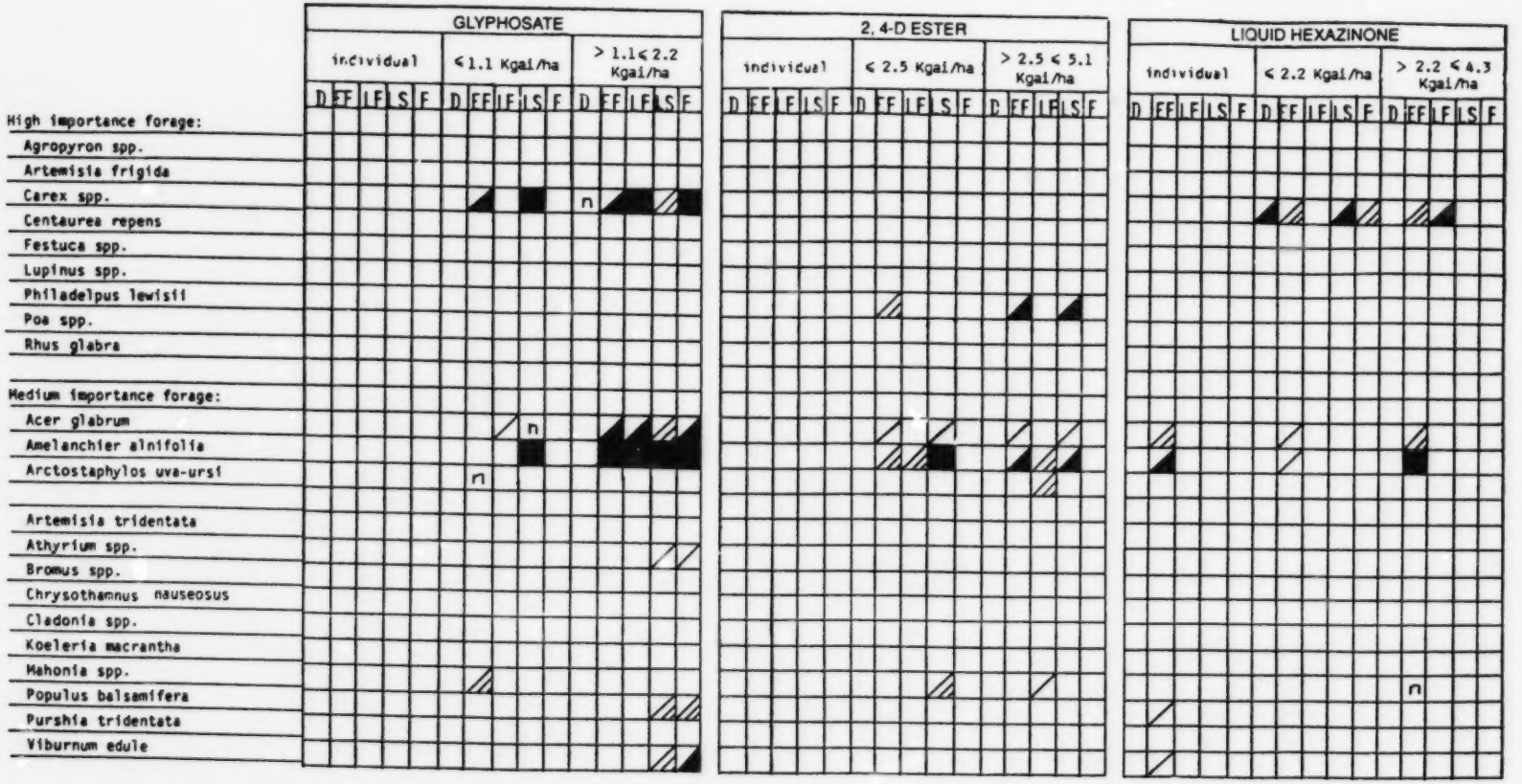


TABLE 5 — *Continued*

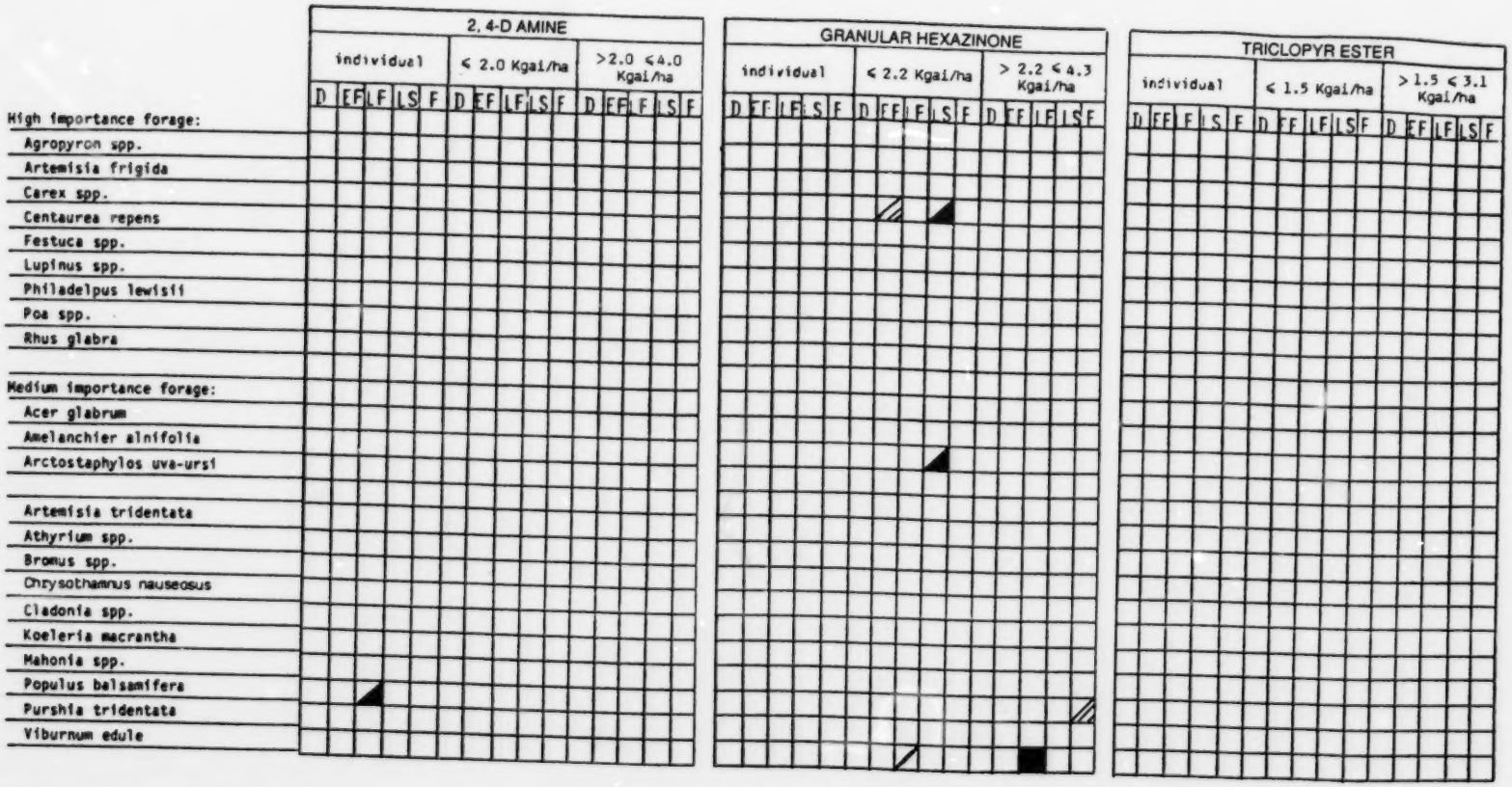
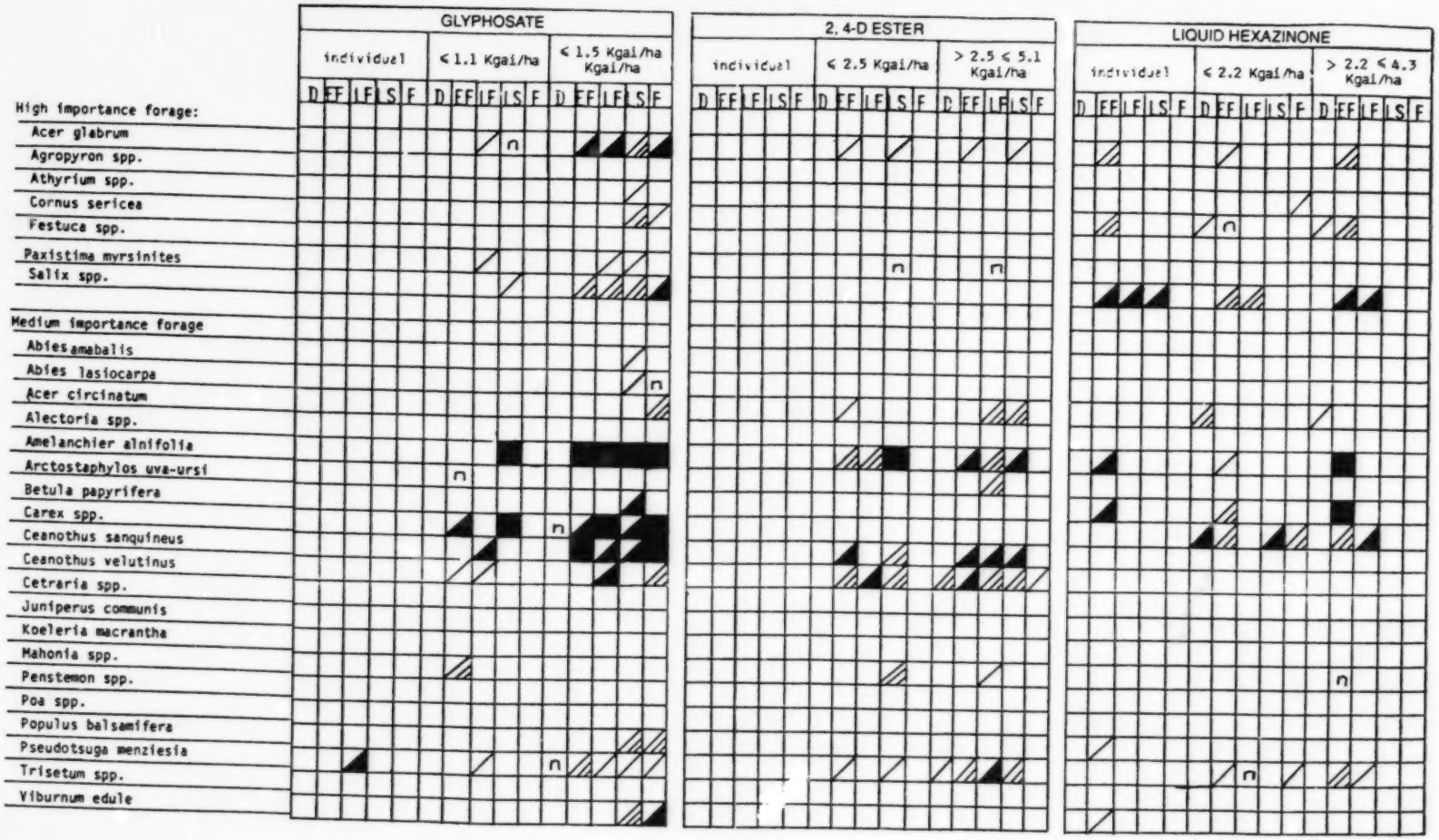


TABLE 6. Mountain Goat forage species data summary



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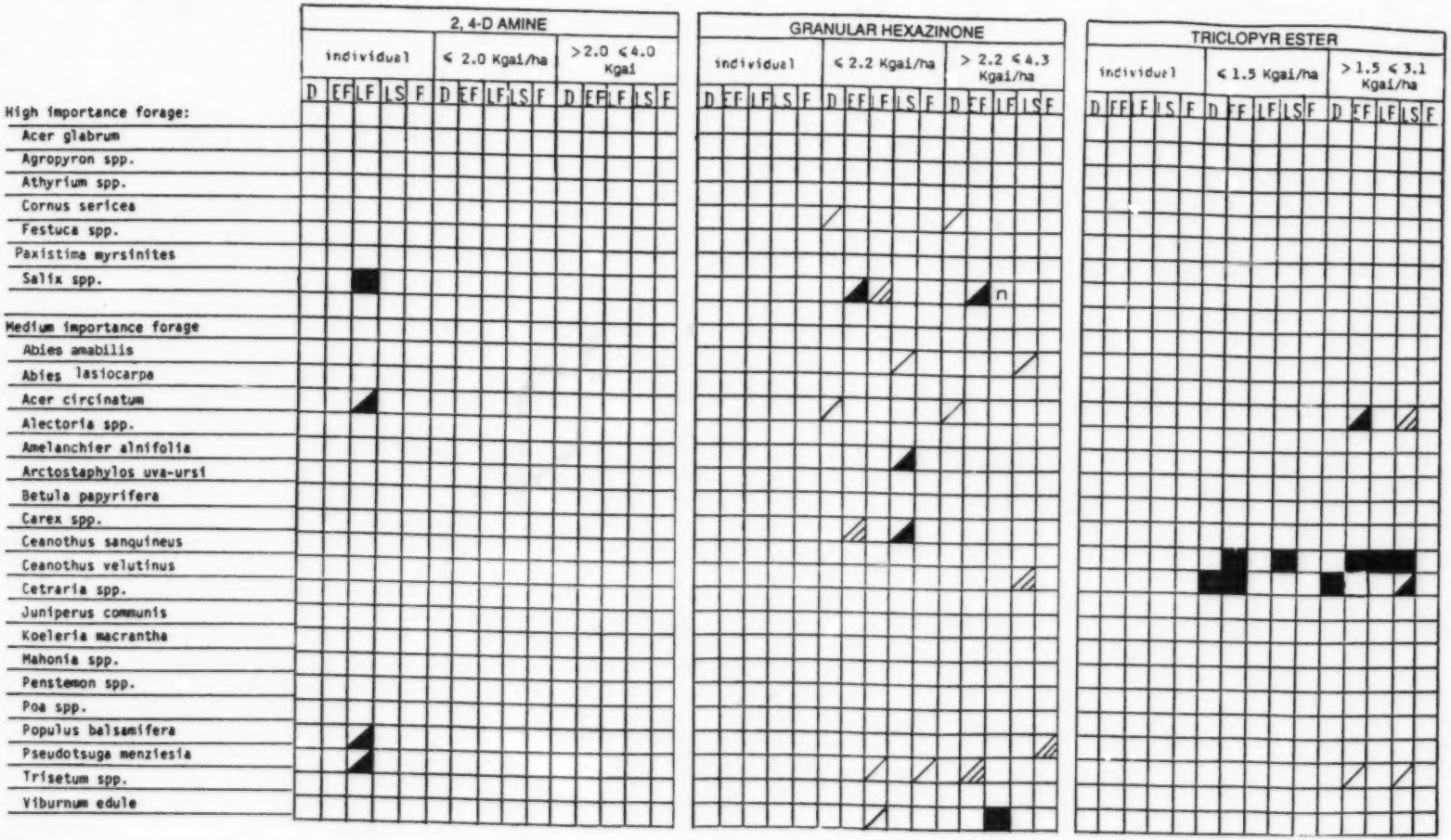
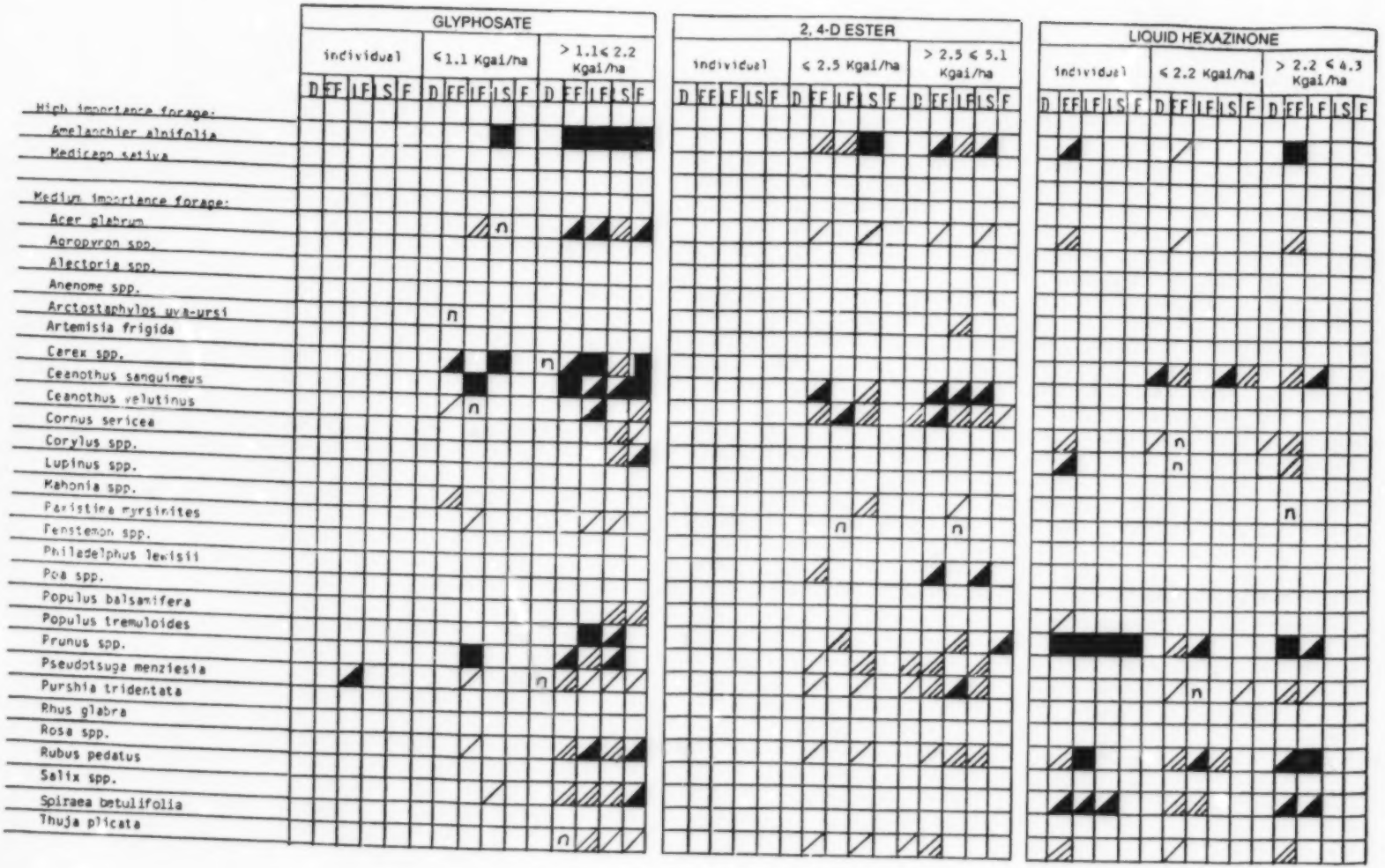


TABLE 7. White-tailed Deer forage species data summary



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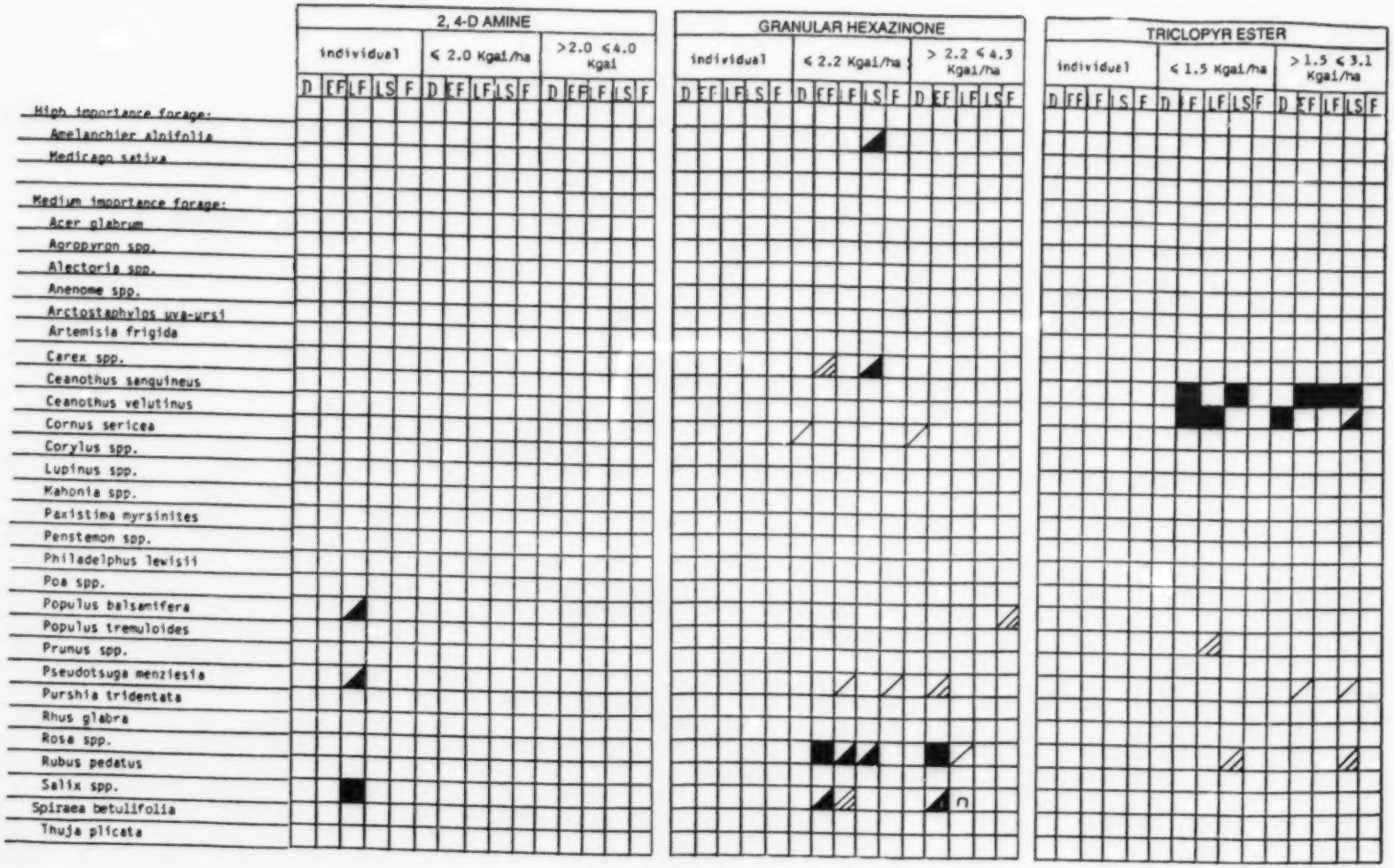
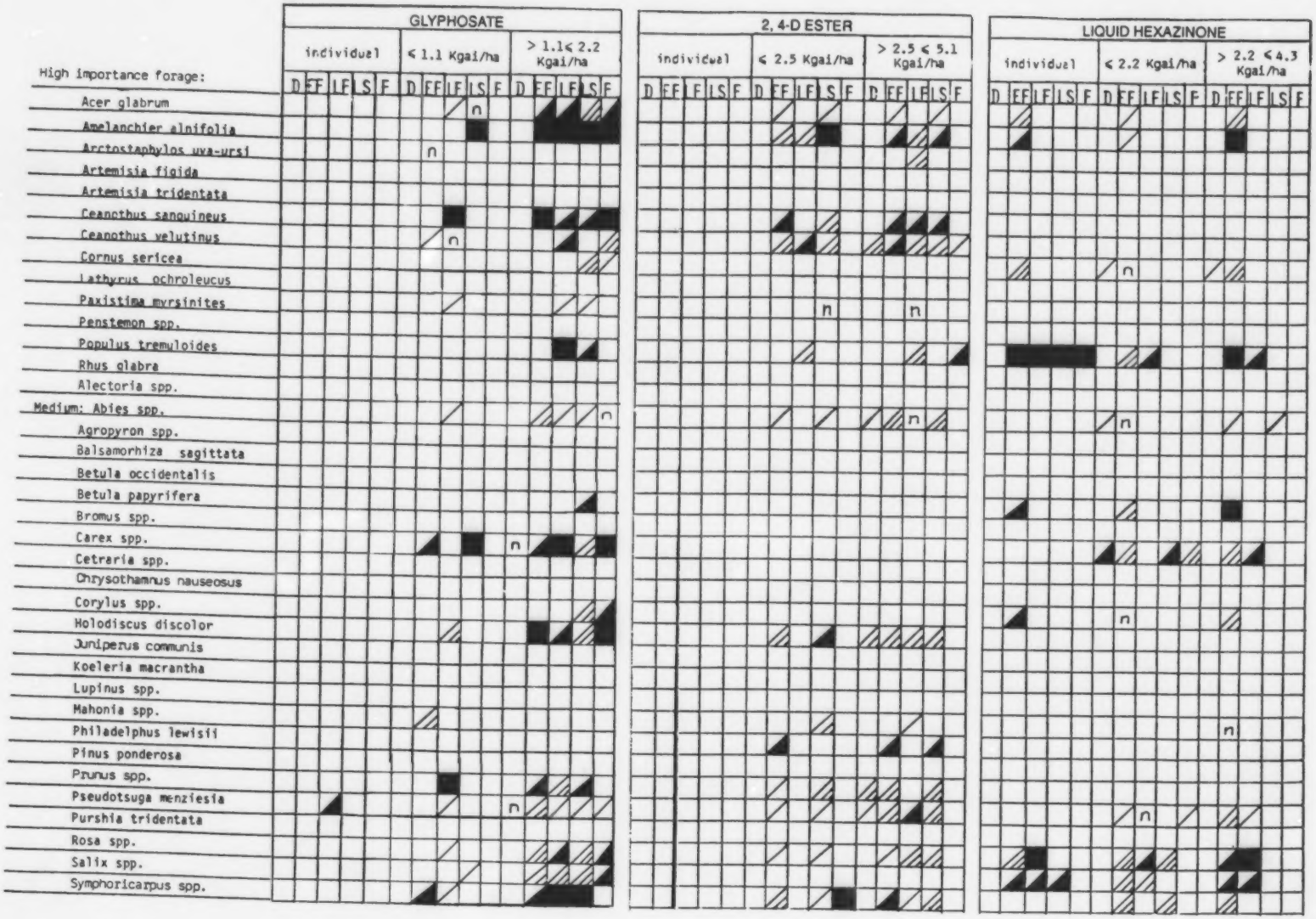


TABLE 8. Mule Deer forage species data summary



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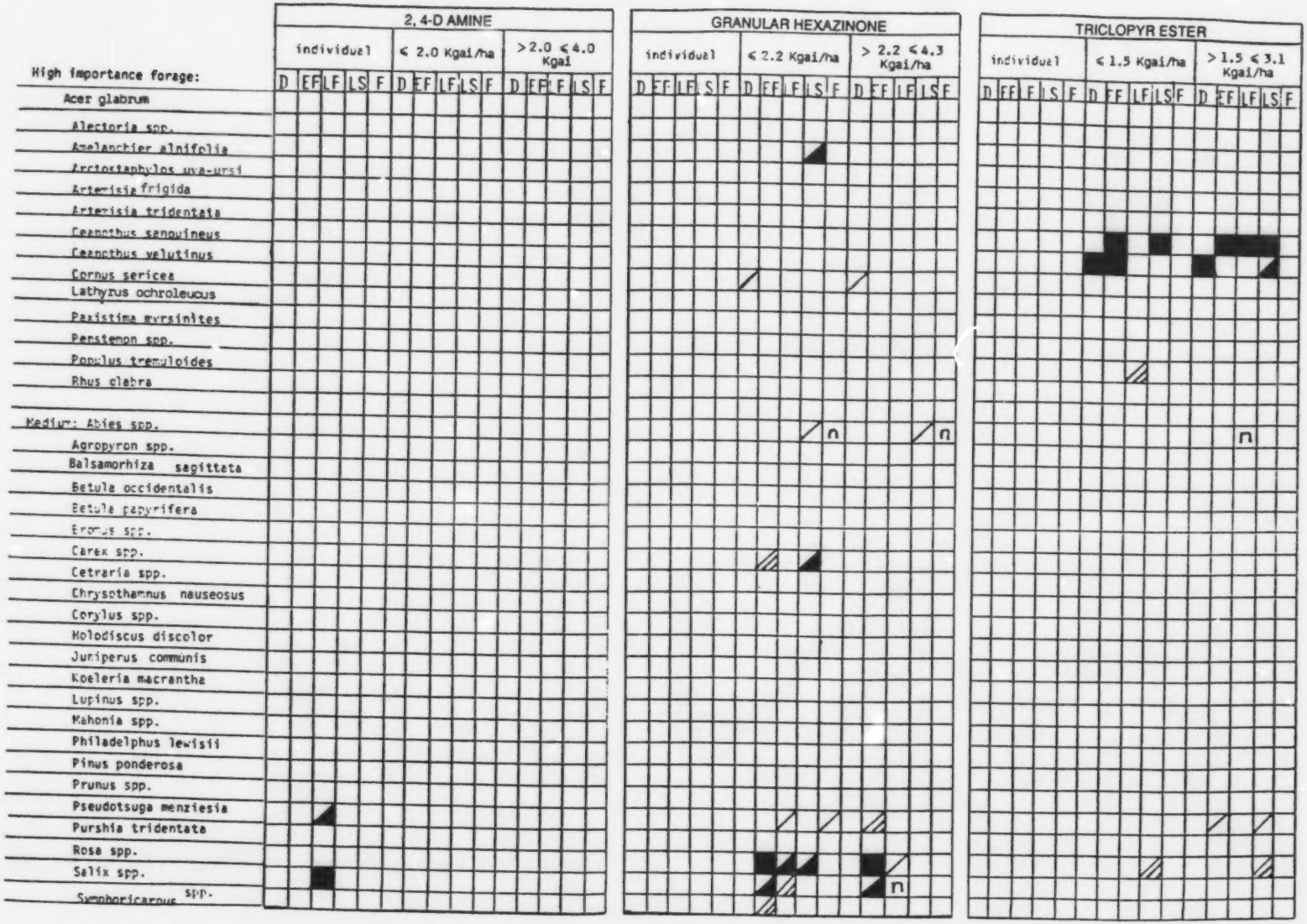
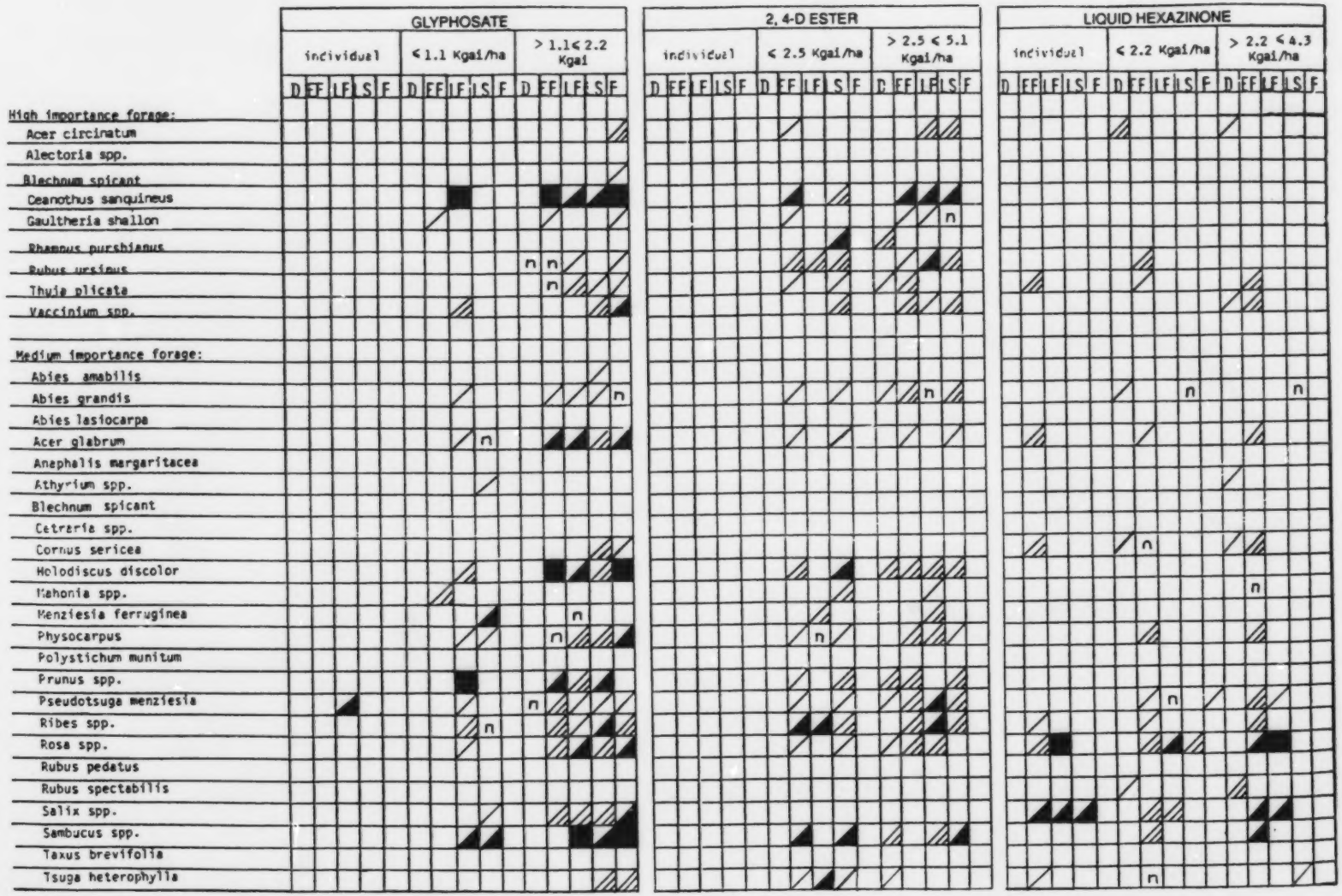


TABLE 9. Coast Black-tailed Deer forage species data summary



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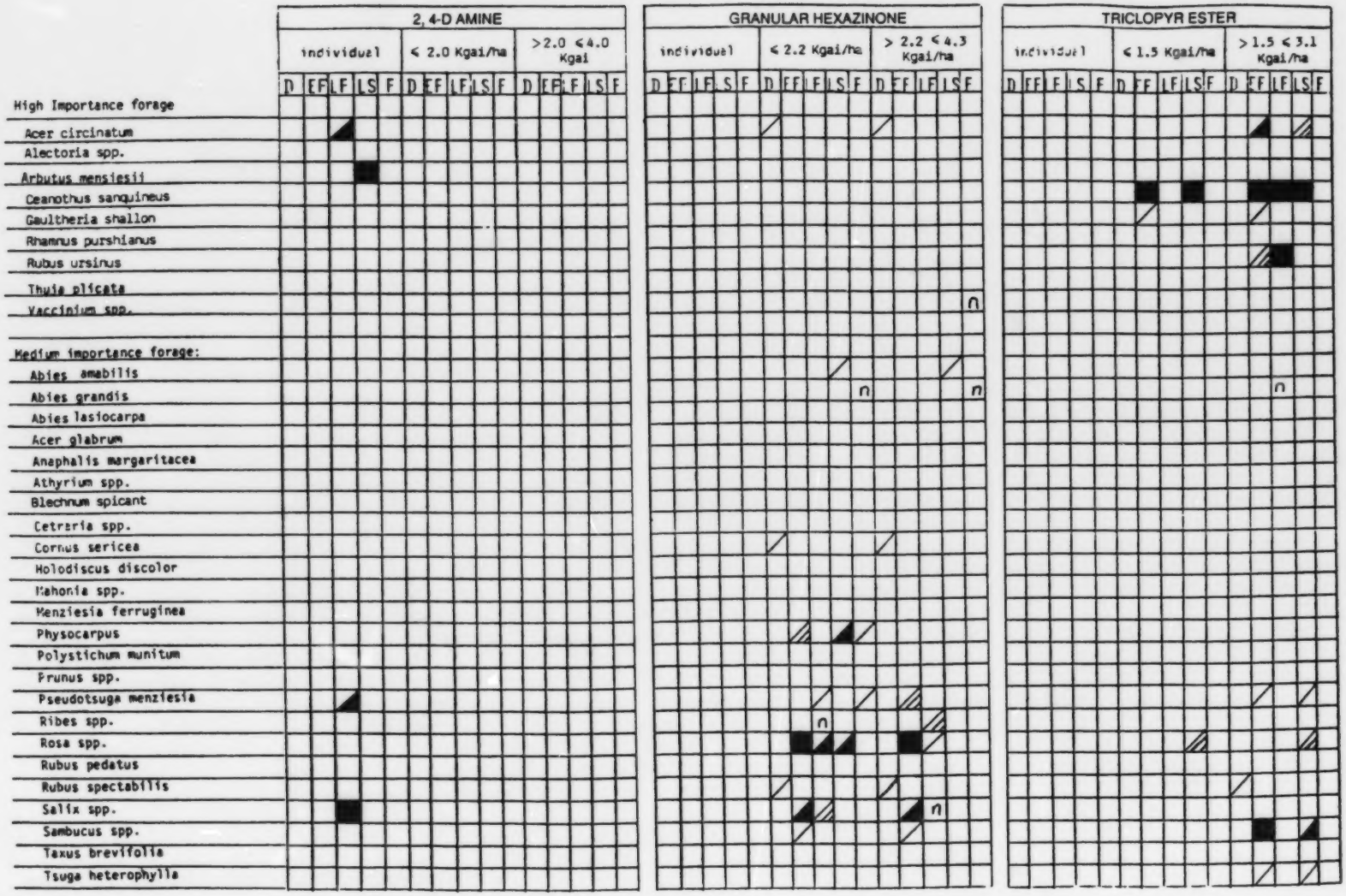
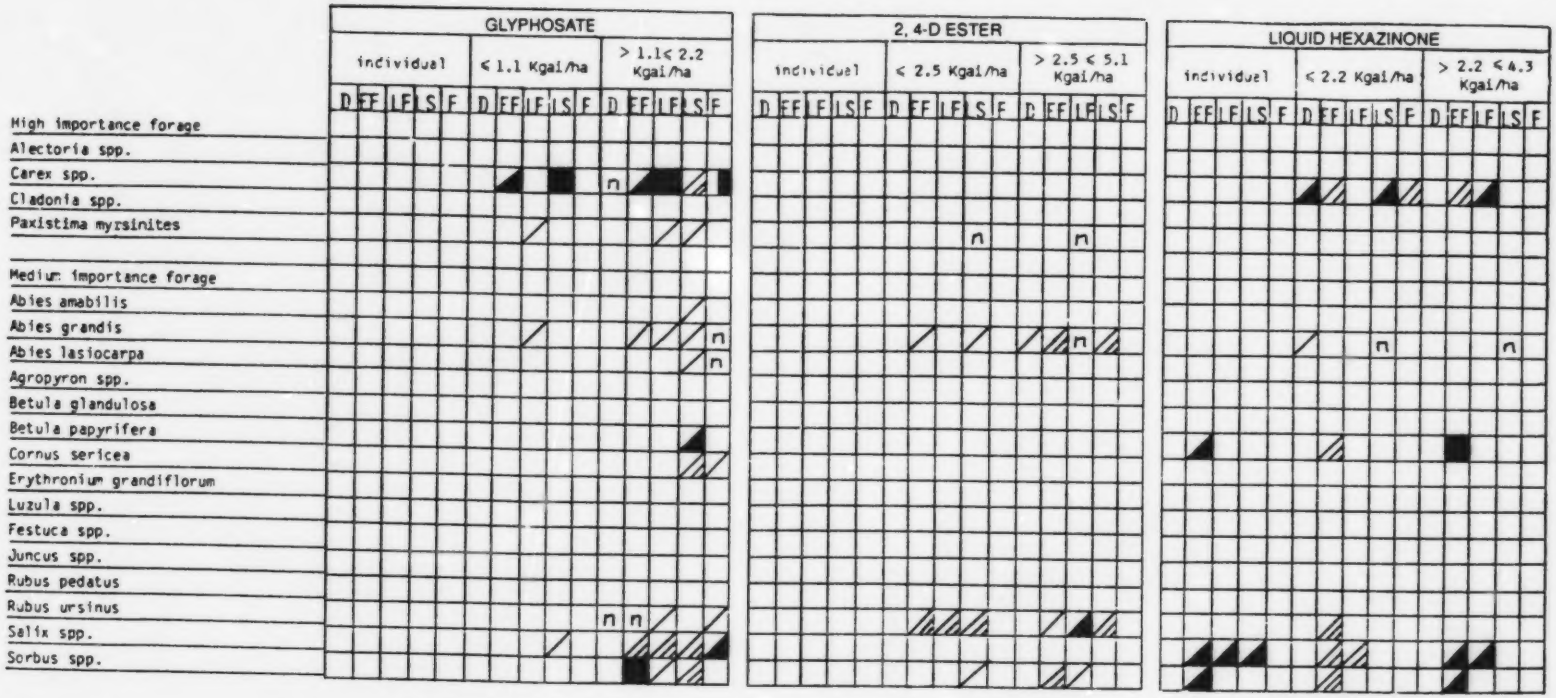


TABLE 10. Caribou forage species data summary



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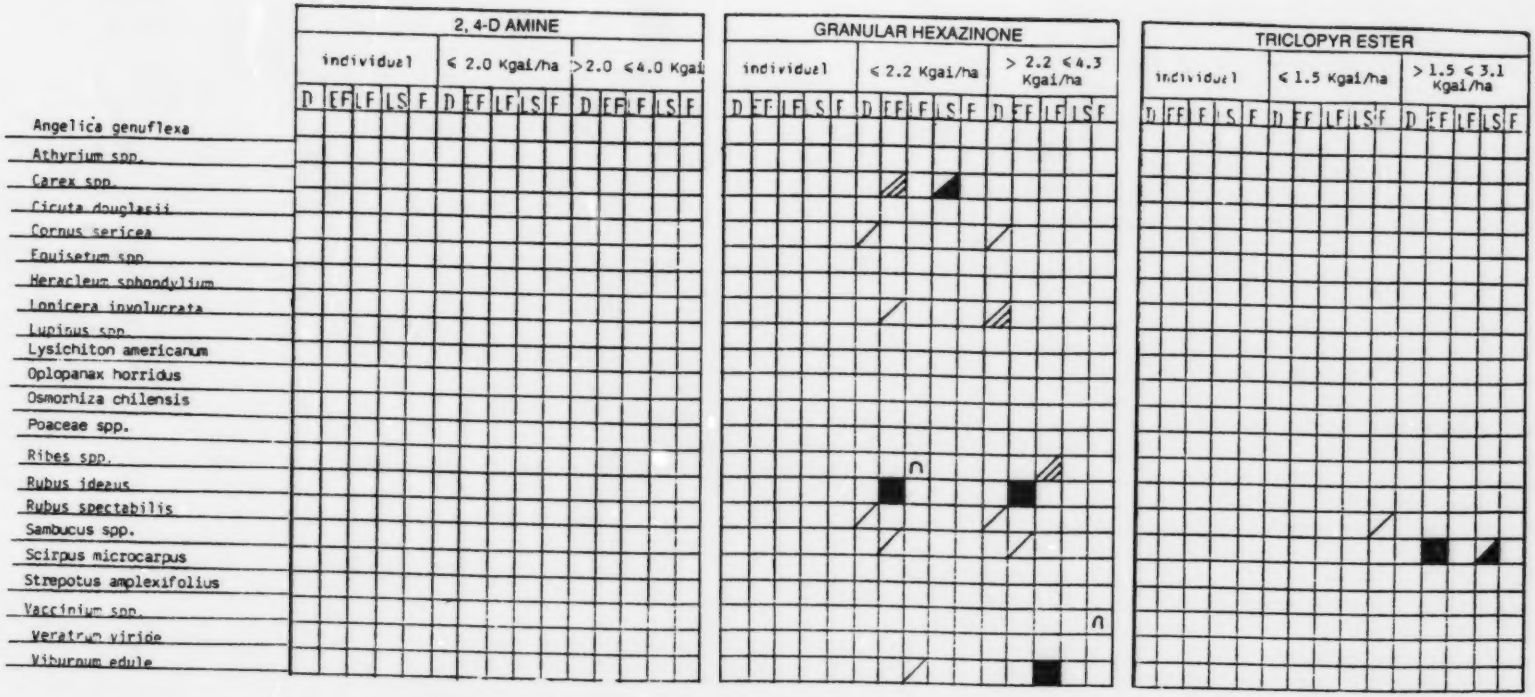
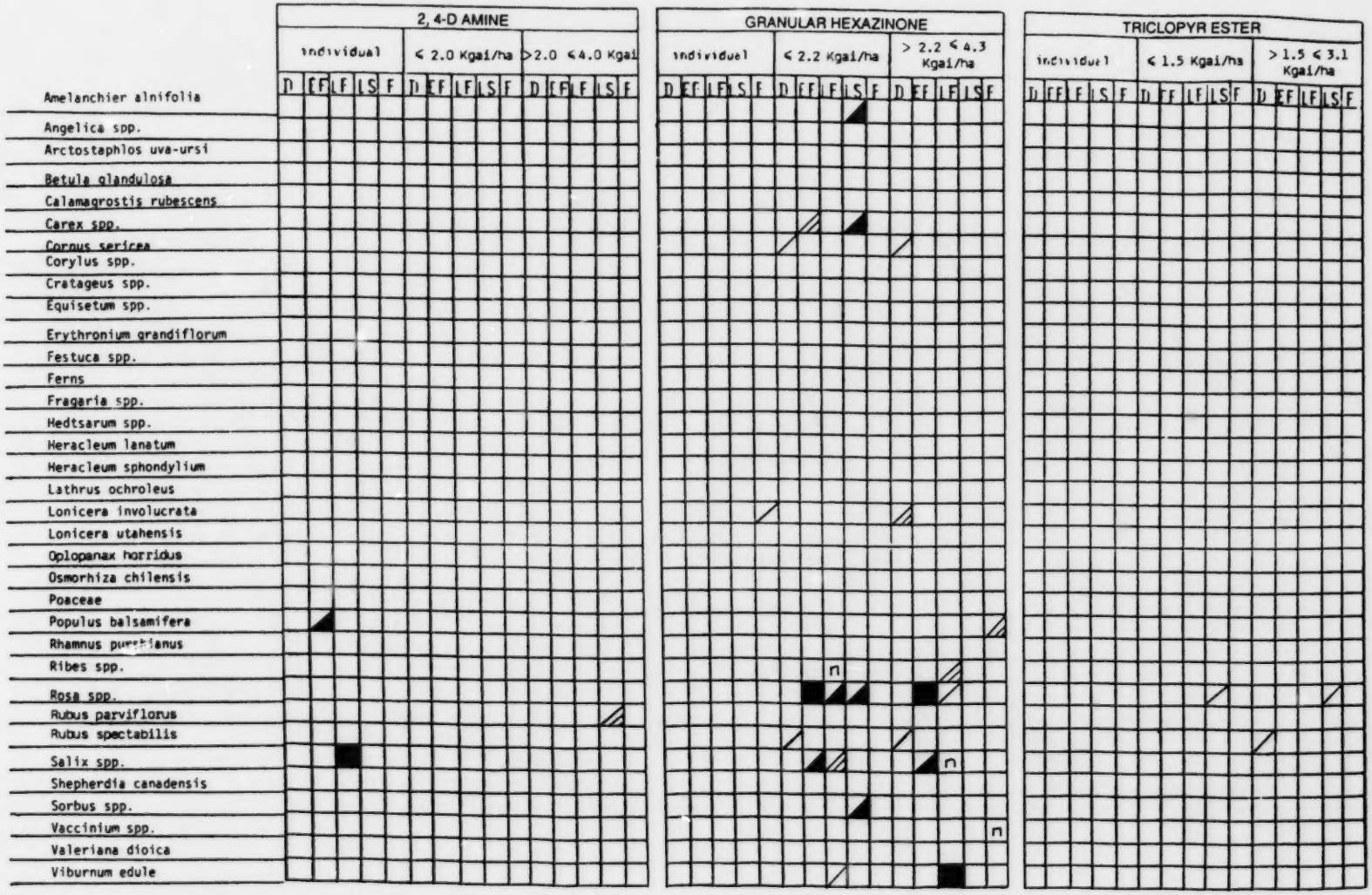


TABLE 11. Interior Grizzly Bear forage species data summary



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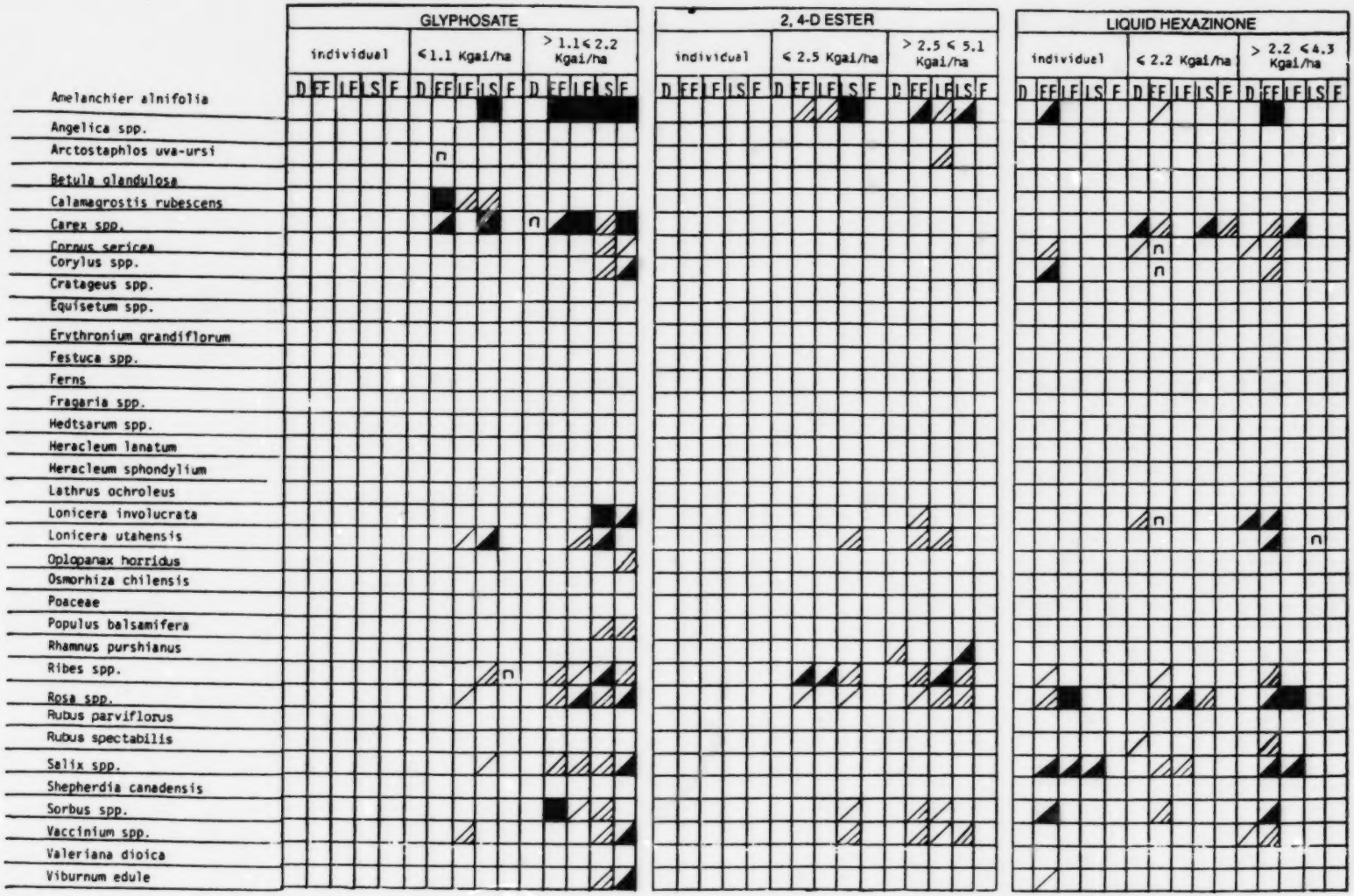
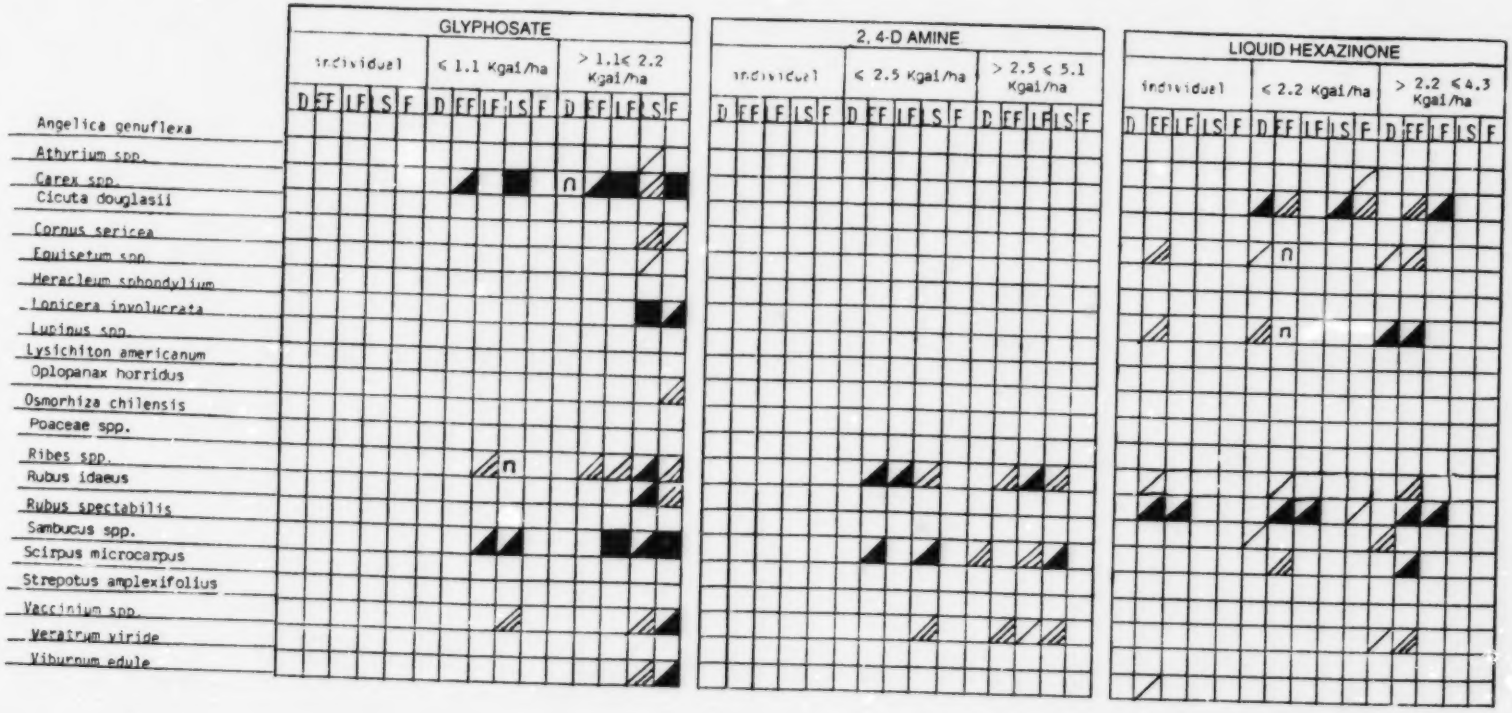


TABLE 12. Coastal Grizzly Bear forage species data summary



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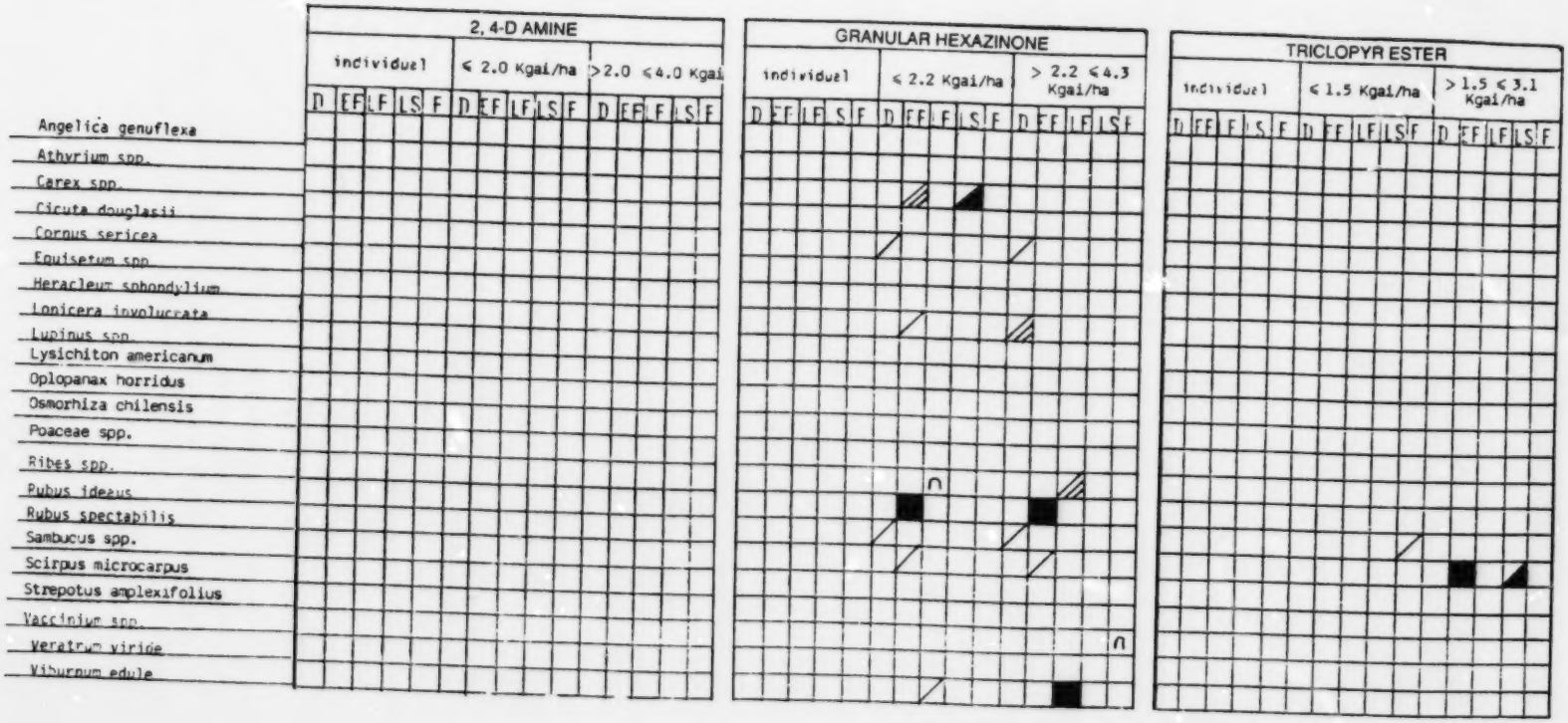

4 SUMMARY OF HERBICIDE EFFECTS ON MAJOR FORAGE SPECIES

For each group of forage species (coniferous trees, deciduous trees, shrubs, and herbaceous species), the effect of herbicide use on the selected major wildlife species is discussed. To be included in the discussion, each forage species required a minimum of five data; species not meeting this requirement are listed in Tables 2–12 in Section 3 to identify this information gap. The data base for each species is first summarized, followed with a discussion of the range of effects by herbicide used, rate, and time of use.

4.1 Conifers

Because of their physiology, conifers are relatively resistant (during most seasons) to herbicide-induced injuries; indeed, it is this characteristic that is exploited in chemical conifer release and brushing treatments. However, conifers are not immune to damage and herbicide manufacturers warn against application during the active growing season (Monsanto Roundup®, Later's Forestamine® and For-Ester®, Pesticide Label Catalogue, Vol. 6, Section 3, 1985). The association between periods of active growth and increased damage is well documented and generally accepted. The DuPont label for Velpar-L® warns, "The effect of Velpar-L® on conifers varies with the soil type, uniformity of application and environmental conditions" (DuPont/Velpar-L®, Pesticide Catalogue, 1985). Further evidence of the variable response of conifers can be found in a study done in the Sierra mountains of California (King and Radosevich 1985). While the authors confirmed the relationship between active growth and increased damage for most species, they concluded that "the degree of injury and relationship of herbicide tolerance to various physiological factors were unique for each species."

- *Abies* spp. — true firs (AB SP)

  Glyphosate: 42 entries
  Liquid hexazinone: 6 entries
  Granular hexazinone: 3 entries
  2,4-D ester: 22 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 1 entry

Of the 74 *Abies* entries analyzed, 11 pertained to *A. lasiocarpa*, 5 to *A. amabilis*, and the remainder to *A. grandis*. Therefore, while *Abies* is discussed in general terms, the interpretation is mainly valid for *A. grandis*.

Thirty-eight of the 42 glyphosate entries analyzed found low to no effect, regardless of rate or season of application. Boyd *et al.* (1985) concluded a moderate injury rating for spring applications, but this is related to a higher rate (3.35 kg ai/ha) and/or the use of additives.

The herbicide 2,4-D ester was found to have a moderate effect on *Abies* in spring and late summer applications at maximum rates. While the results are varied, there does seem to be evidence of increased damage in "summer" applications. Boyd *et al.* (1985) indicated moderate damage for late summer-fall applications, and Kelpsas and Cleary (1981) listed severe damage for summer applications. Although an exception, damage as high as 90% was found for a late summer treatment.

Both granular and liquid hexazinone caused little damage to *Abies* (Boyd *et al.* 1985). Similarly, triclopyr ester had no effect in a summer aerial application at 2.25 kg ai/ha.

With the exception of the granular hexazinone applications, all the fir data represent aerial applications. Boyd *et al.* (1985) cautioned that "conifer damage is often confounded by overlapping, competing vegetation." Furthermore, all the observations are year one results. Where bud injury is evident, it is possible damage may be more severe in following growing seasons.

- *Pseudotsuga menziesii* — Douglas-fir (PS ME)

  Glyphosate: 29 entries
  Liquid hexazinone: 7 entries
  Granular hexazinone: 4 entries

2,4-D ester: 14 entries
2,4-D amine: 1 entry
Triclopyr ester: 2 entries

Broadcast applications of glyphosate at maximum rate generally caused low to no injury to Douglas-fir. Of the 29 entries analyzed, 23 reported less than 26% damage. Virtually all the entries were at the rate of >1.1<2.2 kg ai/ha and from the inland Northwest (Boyd *et al.* 1985). An individual cut-surface treatment, using full-strength glyphosate in the summer, caused severe damage. Individual stem treatments, such as this one, are listed on the manufacturer's label for a "control" method, substantiating this unique entry (Monsanto Roundup® — Pesticide Label Catalogue, Vol. 6, Section 3, 1985).

Most (11 of 14) of the entries for 2,4-D ester fell in the low to moderate injury rating. A cut-surface treatment using 2,4-D amine caused severe damage. Literature reviews show a general consensus of little to no injury for spring applications, but moderate to severe injury for the summer months (Kelpsas and Cleary 1981; Boyd *et al.* 1985).

Hexazinone generally caused little to no damage regardless of granular or liquid formulation and regardless of season. One spring application of liquid hexazinone showed moderate damage.

The reported effects of triclopyr ester contradict one another. Boyd *et al.* (1985) reported very severe injuries as a result of May–July applications and moderate injuries following August–October applications. Alternatively, Kelpsas and Cleary (1981) found both spring and summer applications to cause light injuries. Only the Kelpsas and Cleary data were available in the data base.

- *Tsuga heterophylla* — western hemlock (TS HE)

Glyphosate: 9 entries
Liquid hexazinone: 9 entries
Granular hexazinone: 0 entries
2,4-D ester: 5 entries
2,4-D amine: 0 entries
Triclopyr ester: 0 entries

Contrary to the other conifers studied, hemlock seems susceptible to damage from glyphosate. Nearly all the entries were late summer, at rates of >1.1<2.2 kg ai/ha, and damage was between 25 and 90%. Furthermore, there is severe damage in four instances, listed as year two results. Literature reviews show a general consensus of little to no injury for spring applications, but moderate to severe injury for the summer months (Kelpsas and Cleary 1981; Boyd *et al.* 1985). The Expert Committee on Weeds (1985) reported that hemlock has "excellent tolerance to glyphosate at 6 litres product/ha [2.1 kg ai/ha]" and Kelpsas and Cleary (1981) concluded that both spring and fall applications cause "little to no injury." Unfortunately, no entries have both year one and year two findings, which might show whether damage is increasing, decreasing, or persisting over time.

Liquid hexazinone caused little to no damage regardless of season. One exception, reported by the Expert Committee on Weeds (1985), was that hemlock was found to be sensitive to spot-gun applications of the herbicide. There were no entries related to granular hexazinone effects on hemlock.

With the exception of a single summer application of 2,4-D ester causing severe damage, the remaining applications caused little damage, regardless of rate or season of application.

- *Thuja plicata* — western redcedar (TH PL)

Glyphosate: 10 entries
Liquid hexazinone: 8 entries
Granular hexazinone: 0 entries
2,4-D ester: 4 entries
2,4-D amine: 0 entries
Triclopyr ester: 0 entries

Glyphosate and 2,4-D ester caused no to moderate injury to *Thuja plicata*. Exceptions included one trial which reported severe damage for summer, 2.2 kg ai/ha glyphosate and 2,4-D treatments (Conard and Emmingham 1984d).

Boyd *et al.* (1985) concluded that 2,4-D ester caused little to no damage throughout the growing season, and that glyphosate caused moderate damage in May to July. The Expert Committee on Weeds (1985) lists western redcedar as having "excellent tolerance" to 6 L product/ha (2.1 kg ai/ha) treatments.

British Columbia studies found that spring spot-gun hexazinone treatments, regardless of rate, caused moderate damage.[4] This agrees with the Expert Committee on Weeds (1985) report that cedar demonstrated "Fair to poor tolerance of Velpar-L® at 18/20 L/ha spot-gun applications." Broadcast backpack applications at minimal rates ($>1.1<2.2$ kg ai/ha) caused severe injury.

4.2 Deciduous Trees

- *Betula* spp. — birch (BE SP)

  Glyphosate: 3 entries
  Liquid hexazinone: 40 entries
  Granular hexazinone: 4 entries
  2,4-D ester: 0 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 1 entry

Nearly all of the information on birch is limited to spring, liquid hexazinone treatments. The results show moderate damage at low rates and severe damage at high rates. Spot treatments also caused severe damage (ranging from 43 to 90%), with less injury at the less intensive grid patterns — a trend rarely found by this review for other species. Such a trend suggests birch has an extreme sensitivity to rate of application. The ranges for spring are misleading (Table 3 in Appendix 1). The lesser rate of ≤ 2.2 kg ai/ha shows 2–80% for 13 entries; with the deletion of two entries, the range would be 2–47%. In the higher rate category $>2.2 \leq 4.3$ kg ai/ha, an exceptional "no effect" finding would, if deleted, cause the range of damages to increase to 77–100% for the remaining six entries — clearly a severe response. These two entries could be deleted because they are both from the same trial and some unique experimental conditions may have occurred.

Given the preference of various wildlife species for particular types of birch, much more testing must be done at the species level. Out of 48 entries included here, 40 were early foliar hexazinone trials and the remaining are unknowns.

- *Populus balsamifera* — balsam poplar/black cottonwood (PO BA)

  Glyphosate: 6 entries
  Liquid hexazinone: 1 entry
  Granular hexazinone: 1 entry
  2,4-D ester: 0 entries
  2,4-D amine: 1 entry
  Triclopyr ester: 0 entries

Glyphosate entries were all from Newhouse and Geisler[5] in the Prince Rupert Forest Region; results ranged from low to severe. Haeussler and Coates (1986b) reported that late summer applications of glyphosate at rates of 2.4–3.0 kg ai/ha caused high mortality and little subsequent suckering for balsam poplar. They also concluded that black cottonwood is extremely sensitive to glyphosate at rates of 1.0 kg ai/ha or greater. The data are insufficient to allow accurate conclusions to be drawn.

- *Populus tremuloides* — trembling aspen (PO TR)

  Glyphosate: 9 entries
  Liquid hexazinone: 74 entries
  Granular hexazinone: 7 entries
  2,4-D ester: 6 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 2 entries

[4] Newhouse and Geisler, 1986.
[5] Newhouse and Geisler, 1986.

Glyphosate resulted in 0–100% damage. Of eight of the late summer applications, six were severe and two were low. The latter two entries were at rates of 1.5 kg ai/ha and all the others were 2.0 kg ai/ha. Haeussler and Coates (1986b) cited a study from the Prince George area, where glyphosate at rates greater than 2.0 kg ai/ha "provided excellent control."

Liquid hexazinone caused severe damage in every category for which data were found. Haeussler and Coates (1986b) concluded that hexazinone, whether applied by liquid spray, soil injection, or granules, should provide control.

The 2,4-D ester applications reviewed were highly variable and inconclusive. This finding agrees with Hauessler and Coates (1986b), who cited variable control followed by suckering.

The data for both *Populus* spp. are from western Canada.

4.3 Shrubs

- *Acer circinatum* — vine maple (AC CI)

  Glyphosate: 2 entries
  Liquid hexazinone: 3 entries
  Granular hexazinone: 4 entries
  2,4-D ester: 4 entries
  2,4-D amine: 1 entry
  Triclopyr ester: 2 entries

The following summaries are based on limited data and should be interpreted with caution. For example, fall glyphosate application, recorded as moderate, is an average between a "no effect" and a "60–90% effect." Obviously the data are inconclusive. Kelpsas and Cleary (1981) reported "light injury" when glyphosate is used on vine maple.

Most of the research reflects some degree of species tolerance to herbicide application, with nearly all cases falling into the low to moderate range of damage. Hexazinone, both granular and liquid, in a trial near Chilliwack, caused minimal damage (D'Anjou 1985). These findings, however, are limited to dormant season applications; there are no comparable data on growing season applications. Exceptions of applications causing severe damage are a late summer, cut-surface treatment using 2,4-D amine, and a spring application of triclopyr ester.

- *Acer glabrum* — Douglas maple (AC GL)

  Glyphosate: 17 entries
  Liquid hexazinone: 16 entries
  Granular hexazinone: 0 entries
  2,4-D ester: 9 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

The majority of entries for glyphosate fell within the 60–90% damage range for the higher dosage rates (>1.1<2.2 kg ai/ha). This damage lasts and, in some cases, increases into the third year. So, while the effect may appear to be moderate, persistence of damage due to decreased vigour is a concern. Long-term study is needed. Haeussler and Coates (1986b) registered "good control?" when using glyphosate on Douglas maple, which suggests that a "severe" damage rating may be more appropriate.

All the liquid hexazinone trials were from British Columbia and were performed in the spring. Spot treatments caused 0–60% damage; broadcast applications mainly caused low to moderate damage. Applications at the maximum rate, 4.3 kg ai/ha, approached the damage levels (43%) of the spot treatments. Boyd *et al.* (1985) concluded that late summer and fall applications of liquid hexazinone cause "little or no injury"; these results are excluded from this report because of additives used in those trials.

Applications of 2,4-D ester throughout the growing season, regardless of rate, caused minimal damages. The most severe result was 35% topkill following a late summer, 4.5 kg ai/ha treatment. Furthermore, whenever recorded, topkill was 0% the year following the season in which results were noted.

In a study conducted from 1960 to 1966 (Mueggler and Lyon 1966), in which a 2,4-D/2,4,5-T mixture was used (a combination no longer registered for forestry use), the researchers noted the following:

> Of the 60 plants sprayed in 1960, 46 were located in 1966. The smallest number of plants found for any spray month was 5, for July. Aerial crown kills in the first year after spraying was 50–60%. Five years later, crown densities had increased considerably and dead crowns averaged only 25–30%. Maximum height of live crowns was not decreased by any of the treatments. What little reduction did occur initially was either recovered or exceed by growth during the following five years.

Although initial damages were high, Douglas maple demonstrates good recovery. The literature supports this type of response. Haeussler and Coates (1986a) list "moderate control" and mention that 2,4-D usually results in defoliation or topkill followed by sprouting.

- *Amelanchier alnifolia* — saskatoon (AM AL)

  Glyphosate: 11 entries
  Liquid hexazinone: 17 entries
  Granular hexazinone: 1 entry
  2,4-D ester: 15 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

Glyphosate applications are very damaging to saskatoon, with 100% damage persisting 3 years after application for all seasons and all rates. Indeed, saskatoon seemed the most sensitive of all the species studied, as found in both the inland Northwest trials and Prince Rupert Forest District study (Boyd *et al.* 1985; Newhouse and Geisler[6]). As well, 2,4-D ester severely damaged saskatoon, although at rates less than 2.5 kg ai/ha there was some decrease in damage. Regardless of the rate, damage did persist from year two through year three. Unlike the glyphosate results, the 2,4-D trial results were variable. Further trials may reveal conditions for manipulating damage levels.

Saskatoon responded to amount of liquid hexazinone. Spot treatments for all grid patterns caused severe injury or very severe injury, as did treatments within the maximum rate range. Applications less than or equal to 2.2 kg ai/ha caused less than 25% injury in every case. Some of these data were from year one and some were from year two; because none were from both years, an assessment of persistence is not possible. One study of late summer granular hexazinone application found 60% topkill.

- *Ceanothus sanguineus* — redstem ceanothus (CE SA)

  Glyphosate: 13 entries
  Liquid hexazinone: 0 entries
  Granular hexazinone: 0 entries
  2,4-D ester: 16 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 7 entries

Glyphosate is very damaging to redsteam ceanothus. Regardless of rate, season, method or location, there were no instances of less than 50% damage. In fact, 11 of the 13 entries reported 80–100% topkill. While there does seem to be some recovery in year three, this is often minimal and, in some cases, damage persists. Virtually all the entires are from Boyd *et al.* (1985). Their assessment is that glyphosate causes "very severe injury or kill," May to October. In contrast, Kelpsas and Cleary (1981) reported little or no injury following fall applications.

Applications of 2,4-D ester also cause severe damage for both rates of application and late summer and spring treatments. Furthermore, the damage persists at a severe level into year three. These findings can be compared to Mueggler and Lyon's (1966) study:

> In all, only 10 of the orignal 60 plants were found alive and the vigour of several of these appeared to be very poor . . . 50% of the summer treatments were dead six years later and 100% of the spring treatment plants were dead one year later.

[6] Newhouse and Geisler, 1986.

Thus, not only is redstem ceanothus very sensitive to phenoxy herbicides, but the resultant damage is persistent.

Triclopyr ester was also found to cause severe injury. This extreme sensitivity of redstem ceanothus to all chemicals used in British Columbia is unfortunate, given its value as a forage species in several locations.

- *Ceanothus velutinus* — snowbrush (CE VE)
  Glyphosate: 7 entries
  Liquid hexazinone: 0 entries
  Granular hexazinone: 1 entry
  2,4-D ester: 18 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 6 entries

Unlike redstem ceanothus, snowbrush appears to have some tolerance to glyphosate. Even at the high rate of 3.35 kg ai/ha, damage was between 20 and 40% for summer and late summer applications (Boyd *et al.* 1985). (These data were not included in the tabular analysis because they exceed the Canadian registration rate.) This example of variation within a genus highlights the need for research within the other important forage genera — such as willows, grasses, and birches — where treatment results are often grouped at the genus level. It is possible the resistance noted is a function of snowbrush being evergreen as opposed to redstem ceanothus being deciduous.

Application of 2,4-D ester resulted in moderate to severe damage. This effect is based on averaged results of second and third year responses; most likely initial damage was more severe and recovery is moderating the results. Evidence of persisting levels of damage is important when forage response is being considered.

Triclopyr ester caused severe or very severe injury.

- *Cornus sericea* — red-osier dogwood (CO SE)
  Glyphosate: 8 entries
  Liquid hexazinone: 15 entries
  Granular hexazinone: 2 entries
  2,4-D ester: 0 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

The limited data available on the effects of glyphosate on dogwood suggest moderate to severe damage for late summer applications, and light damage for fall applications at rates of $>1.1<2.2$ kg ai/ha.

Evidence of some tolerance to liquid hexazinone was demonstrated. Spring spot treatments and maximum rate treatments caused low to moderate damage; dormant season and minimal rate treatments caused low to no damage.

Haeussler and Coates (1986b) cited a study in Oregon that found "Spraying with 2,4-D . . . prior to vegetative maturity caused tip die-back, damaged foliage and delayed spring budbreak and growth . . ."

- *Corylus* spp. — Hazelnuts/Filberts (CO SP)
  Glyphosate: 3 entries
  Liquid hexazinone: 7 entries
  Granular hexazinone: 0 entries
  2,4-D ester: 0 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

The three data entries for *Corylus* were from the Prince Rupert Forest Region.[7] Two late summer glyphosate treatments caused moderate injury; one fall application resulted in severe damage. Kelpsas and Cleary (1981)

[7] Newhouse and Geisler, 1986.

also reported that fall applications killed hazelnuts. Sutton (1978) reported "severe injury-kill, persisting over three years."

Liquid hexazinone had a moderate effect for two broadcast treatments at higher rates, but no effect for one treatment at a rate of 1.07 kg ai/ha. Four spot treatments had severe effects. These were all spring applications.

While data specific enough for entry in the 2,4-D data base were not found, Haeussler and Coates (1986b) reported that 2,4-D produced "heavy topkill in hazelnut, but resprouting can be vigorous." They also noted conflicting results: some researchers reported spring applications to be "most effective", while others claimed summer applications to be "most effective." Kelpsas and Cleary (1981) found that spring and fall applications caused light injury, while summer applications caused severe injury. Variation is often the norm in herbicide tolerance trials, and perhaps the only conclusion to be made is that *Corylus* has demonstrated the potential to be severely damaged by 2,4-D.

The only reference to the other herbicides was from Kelpsas and Cleary (1981) who found spring and summer applications of triclopyr ester to cause light injury.

- *Gaultheria shallon* — salal (GA SH)

  Glyphosate: 5 entries
  Liquid hexazinone: 0 entries
  Granular hexazinone: 0 entries
  2,4-D ester: 5 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 4 entries

This hardy evergreen shrub with its leathery leaves is barely, if ever, injured by any of the applications studied. The physiological characteristics associated with its evergreen habit offer resistance. The limited findings analyzed in this report found glyphosate, triclopyr ester, and 2,4-D ester all to cause less than 25% damage. Similarly, Haeussler and Coates (1986a) concluded that both 2,4-D and gyphosate have "poor to no control."

Hexazinone causes little to no injury to salal (K. Teskey, DuPont Chemicals, pers. comm.). One exception to salal's herbicide resistance is found in Kelpsas and Cleary (1981): triclopyr ester mixed with oil and applied in the spring caused severe injury.

- *Holodiscus discolor* — ocean-spray (HO DI)

  Glyphosate: 12 entries
  Liquid hexazinone: 0 entries
  Granular hexazinone: 0 entries
  2,4-D ester: 15 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

Glyphosate generally injures ocean-spray severely to very severely. Although results are variable, there have been incidences of 100% damage for all seasons — damage that is persistent. These results are all from the inland Northwest (Conard and Emmingham 1983, 1984c; Boyd *et al.* 1985). Boyd *et al.* (1985) concluded that glyphosate caused severe to very severe injury throughout the growing season, and Kelpsas and Cleary (1981) concluded that fall applications "kill" ocean-spray.

Highly variable findings were reported for 2,4-D ester. Table 3 (Appendix 2) reveals that almost every category of season and rate summarized is an average of results from low to severe damage, none of which are accompanied by more than four pieces of data.

Holodiscus was one of the plants in Mueggler and Lyon's (1966) 6-year study:

> There is little question that this species is extremely sensitive to herbicides (2,4-D/2,4,5-T) at any time tested. Every treatment except the May spraying caused an average crown kill of more than 90% on at least nine of ten plants. Moreover, dead crown averaged nearly 50% on all plants relocated in 1966 and none of the treatment groups regained prespray height. Basal sprouting of rockspirea (ocean-spray)

was generally abundant in the initial year, especially for July and August treatments. However, this reaction did not persist, and by 1966 even the most prolific group (July) averaged only three sprouts per plant.

This study highlights the need for long-term study of the effects of herbicides on wildlife forage, because initial bursts in growth can not be assumed to ensure survival. Boyd *et al.* (1985) concluded that 2,4-D ester caused "severe injury, May–July", and "very severe injury or kill, August–October." Kelpsas and Cleary (1981), however, found spring and fall applications to cause light injury and summer applications to cause severe injury. Although no clear damage patterns appear, evidence indicates ocean-spray is sensitive to both glyphosate and 2,4-D ester.

- *Lonicera involucrata* — black twinberry (LO IN)

  Glyphosate: 8 entries
  Liquid hexazinone: 9 entries
  Granular hexazinone: 2 entries
  2,4-D ester: 0 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

Glyphosate appears to result in severe or very severe damage to black twinberry. This conclusion is based on late summer and fall applications in the Prince Rupert Forest Region.[8] Haeussler and Coates (1986a) concluded "excellent control?" Dormant season applications of hexazinone near Chilliwack had variable effect (D'Anjou 1985). A sensitivity to rate was demonstrated in both granular and liquid applications, the lower rates causing low to moderate damage and the higher rates causing moderate to severe damage. This same sensitivity was demonstrated by some spring applications, a 4.3 kg ai/ha treatment causing severe damage and a 1.07 kg ai/ha treatment causing no effect. Haeussler and Coates (1986a) reported "good control?" for liquid hexazinone. Their information was not accompanied by either timing or rate qualifications so the "?" may indicate a range of results due to varying application rates.

- *Lonicera utahensis* — Utah honeysuckle (LO UT)

  Glyphosate: 5 entries
  Liquid hexazinone: 3 entries
  Granular hexazinone: 0 entries
  2,4-D ester: 4 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

Lonicera utahensis response to glyphosate generally showed more than 50% damage, regardless of treatment, for year two, and persisting or increasing damage levels in year three. All the entries were from Boyd *et al.* (1985) trial summaries.

The results for liquid hexazinone are inconclusive, based on only three pieces of data. Two Expert Committee on Weeds (1985) trials report spring applications to cause severe defoliation, while Boyd *et al.* (1985) found a late summer trial to cause 0% topkill.

With only four pieces of data for this report, 2,4-D ester treatments are equally difficult to assess. Three aerial treatments caused 58% topkill in year two, two treatments recovered completely, and one treatment did not recover at all. The one other entry was a spot treatment, which resulted in only 10% topkill, perhaps because less chemical was received by the plant than in the broadcast treatments.

- *Mahonia* spp. — Oregon-grape (MA SP)

  Glyphosate: 2 entries
  Liquid hexazinone: 1 entry
  Granular hexazinone: 0 entries
  2,4-D ester: 4 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

[8] Newhouse and Geisler, 1986.

Very little information (seven entries) was found on *Mahonia*. What results there are indicate moderate to light damage from glyphosate, 2,4-D ester, and liquid hexazinone treatments. With its tough leaves and waxy cuticles, it is not surprising that this plant appears to have some resistance to herbicide-induced damage.

- *Paxistima myrsinites* — falsebox (PA MY)
  Glyphosate: 5 entries
  Liquid hexazinone: 0 entries
  Granular hexazinone: 0 entries
  2,4-D ester: 6 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

Like salal and Oregon-grape, *Paxistima*, with its tough, leathery leaves and evergreen habit, appears to be resistant to herbicide treatments. Virtually all the entries (glyphosate and 2,4-D ester) report light or no damage.

- *Physocarpus malvaceus* — mallow ninebark (PH MA)
  Glyphosate: 14 entries
  Liquid hexazinone: 3 entries
  Granular hexazinone: 0 entries
  2,4-D ester: 12 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

Glyphosate damage averaged moderate for higher rates of application, and low for lower rates. One early spring application at the higher rate, however, showed no damage, and one fall application showed severe damage.

Although the 2,4-D ester data are variable, damage was generally light to moderate at higher dosages and light to non-existent at lower dosages. Persistence of damage was inconclusive. Mueggler and Lyon (1966) reported variable sensitivity and persistent damage:

> Of 60 plants sprayed 46 were found again. Crown kills were most pronounced on plants sprayed in June and September. Even six years after spraying, dead crowns averaged more than 70% for those treatment periods. Plants sprayed in August showed relatively low susceptibility to herbicides (2,4-D and 2,4,5-T). Sprout numbers the first year after spraying did not exceed three per plant; after 6 years sprouts averaged fewer than 0.5 per plant. In contrast to Rock spirea (ocean-spray), ninebark usually recovered through regrowth on the orignal rather than through growth of basal sprouts.

The table summaries for the effects of liquid hexazinone are misleading because of the lack of data and borderline results. Spring <2.2 kg ai/ha applications were both 60%, 1% short of the severe category. Also the spring >2.2<4.3 kg ai/ha applications were 40% and 70%, averaging to a moderate effect. Boyd *et al.* (1985) reported the potential for serious injury for May to October liquid hexazinone applications.

- *Prunus* spp. — wild cherries (PR SP)
  Glyphosate: 9 entries
  Liquid hexazinone: 0 entries
  Granular hexazinone: 0 entries
  2,4-D ester: 9 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

Glyphosate is very damaging to wiid cherry. Only three out of nine entries fell below 61% damage, and in every instance where third year measurements were made, damage had persisted or increased. Sutton (1978) states, "Glyphosate was highly effective in killing pin cherry (*Prunus pennsylvanica*)." There was only one trial from British Columbia. It found a late summer application of glyphosate to cause 100% damage when the site was visited in the year following application.

With 2,4-D ester, injuries in the 40–60% range resulted without apparent sensitivity to rate, season, or method of application. It is worth noting that the results themselves were moderate and not simply moderated because of averaged figures.

- *Ribes* spp. — currants (RI SP)
  Glyphosate: 19 entries
  Liquid hexazinone: 16 entries
  Granular hexazinone: 3 entries
  2,4-D ester: 39 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

The effects of glyphosate on *Ribes* were highly variable; virtually every category for which a summary was made was based on a range of results from low to severe, with no apparent trends. Nevertheless, damage was generally moderate to severe at the higher rates (i.e., >1.1<2.2 kg ai/ha), including damage recorded using rates higher than registration maximum. Boyd *et al.* (1985) concluded that glyphosate caused "severe injury or kill" when applied throughout the growing season.

Damage from 2,4-D ester is also variable. Although the entries range from 0 to 100%, those reporting minimal damage were less frequent. A ground drench method of application was employed in the majority of entries, although no pattern is associated with drench, backpack, or aerial treatment methods.

Late summer applications were noticeably less damaging (0–70%) with an average in the moderate range. Haeussler and Coates (1986a) reported *Ribes bractesosum* to be "moderately controlled."

According to the data available for this report, liquid hexazinone treatments result in light damage for spring applications at low rates and moderate damage at higher rates. Boyd *et al.* (1985) concluded that damage is very severe or kills the species for spring applications of liquid hexazinone, regardless of rate or method. The importance of distinguishing between species is apparent. Black currants are susceptible to 2,4-D and red currants are not (Ashton and Crafts 1981).

- *Rosa* spp. — roses (RO SP)
  Glyphosate: 18 entries
  Liquid hexazinone: 49 entries
  Granular hexazinone: 8 entries
  2,4-D ester: 16 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 6 entries

For application rates >1.1<2.2 kg ai/ha, glyphosate caused moderate to severe damage regardless of season. Summer applications showed damages persisting into the following growing season. Boyd *et al.* (1985) concluded that glyphosate causes severe injury, regardless of season. For fall applications both Newhouse and Geisler[9] and Conard (1984a–d) found instances of severe injury.

For all categories for which information was found, hexazinone caused severe injury to roses — except in spring and summer applications at the minimal rate. The Expert Committee on Weeds (1985) report spot-gun treatments of Velpar-L® to have "excellent control" over roses.

However, roses seem tolerant of 2,4-D ester. In several trials performed in northern Alberta, roses displayed low or no response to 2,4-D ester applications. Although damage as high as 70% was noted in some late summer applications, this was exceptional.

The triclopyr ester applications were very damaging initially, yet showed remarkable recovery (see Appendix 1).

[9] Newhouse and Geisler, 1986.

- *Rubus* spp. — raspberry/thimbleberry/salmonberry (RU SP)

Because of variations in response to herbicide application within the *Rubus* genus, each species is discussed separately below. Users are directed to the wildlife forage tables for information gathered on a species basis.

- *Rubus ideaus* — red raspberry (RU ID)

Glyphosate: 9 entries
Liquid hexazinone: 24 entries
Granular hexazinone: 4 entries
2,4-D ester: 0 entries
2,4-D amine: 0 entries
Triclopyr ester: 0 entries

Late summer and fall applications of glyphosate caused moderate to severe damage in the Prince Rupert Forest Region. Effects ranged from moderate to severe damage or kill (60–100%).[10] However, raspberry has been found to be an "increaser" after 1–2 years, with moderate to high rates of glyphosate applied for conifer release (J. Pollack, B.C. Ministry of Forests, pers. comm., 1987).

Hexazinone also caused severe damage but the results were highly variable within each category. Fall applications of granular hexazinone, however, resulted in 95–100% damage for both lower and higher rates.

- *Rubus parviflorus* — thimbleberry (RU PA)

Glyphosate: 10 entries
Liquid hexazinone: 35 entries
Granular hexazinone: 0 entries
2,4-D ester: 0 entries
2,4-D amine: 0 entries
Triclopyr ester: 0 entries

The data, all from the Prince Rupert Forest Region, showed glyphosate to cause moderate to severe damage.[11] Boyd *et al.* (1985) also found severe damage to thimbleberry resulted when glyphosate was applied throughout the growing season. Haeussler and Coates (1986a) reported "good to variable control", and the Expert Committee on Weeds (1985) report glyphosate to have "excellent control."

Results for liquid hexazinone applications were highly variable, from low to 100% injury. Both Haeussler and Coates (1986a) and the Expert Committee on Weeds (1985) reported that control effects of hexazinone were poor.

- *Rubus spectabilis* — salmonberry (RU SP)

Glyphosate: 0 entries
Liquid hexazinone: 6 entries
Granular hexazinone: 2 entries
2,4-D ester: 0 entries
2,4-D amine: 0 entries
Triclopyr ester: 2 entries

No glyphosate entries were found, and thus nothing is shown on the tables. The literature indicates, however, that glyphosate is very damaging to salmonberry. Both Haeussler and Coates (1986a) and the Expert Committee on Weeds (1985) reported "excellent control"; Kelpsas and Cleary (1981) found glyphosate to kill salmonberry if it was applied in the fall.

Liquid hexazinone caused moderate damage when applied during the dormant season; unfortunately no information was found to determine a response during the growing season. Granular hexazinone caused little injury when applied during the dormant season.

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[10] Newhouse and Geisler, 1986.
[11] Newhouse and Geisler, 1986.

The literature reports 2,4-D ester as causing poor to moderate control (Kelpsas and Cleary 1981; Haeussler and Coates 1986a).

Triclopyr ester caused light injury in a fall application.

- *Rubus ursinus* — trailing blackberry

Glyphosate: 9 entries
Liquid hexazinone: 1 entry
Granular hexazinone: 0 entries
2,4-D ester: 14 entries
2,4-D amine: 0 entries
Triclopyr ester: 5 entries

The glyphosate data base for blackberry is inconclusive. The only category with more than one entry is summer at the higher rate (>1.1<2.2 kg ai/ha). Four out of the six late foliar entries record no damage, one entry records moderate damage, and another entry records severe damage. No further research was found for comparison.

The single liquid hexazinone entry found moderate damage.

The data for 2,4-D ester (all from the United States) fell within the moderate damage range (Boyd *et al.* 1985).

- *Salix* — willows (SA SP)

Glyphosate: 33 entries
Liquid hexazinone: 63 entries
Granular hexazinone: 9 entries
2,4-D ester: 0 entries
2,4-D amine: 1 entry
Triclopyr ester: 2 entries

Glyphosate results for willow were highly variable. The effects noted ranged between 0 and 100% injury for both the Prince Rupert study[12] and the United States inland Northwest trials. Haeussler and Coates (1986b) pointed out that: "Herbicide response in willows is difficult to monitor because of the difficulty in identifying willow species. Because of the great variability both between and within species, herbicide response can vary dramatically." Analysis of the data in this review showed no identifiable relationship between rate, season, method, or location of application. Because willow is one of the most important forage species for ungulates, trials are necessary to determine response on a species level and, within these, species-specific tolerances by rate and season.

The entries for liquid hexazinone were equally variable. However, the majority of entries recorded severe injury with a few "low injury" exceptions, rather than variance throughout. A tendency toward increased damage with increased rate of application was also noted. Granular applications applied in spring caused 95–98% damage in trials in Alberta (Expert Committee on Weeds 1985) and 2% damage in a trial in Chilliwack, B.C. (D'Anjou 1985). It is not possible to determine whether this kind of contradiction is related to species or environment. Given the soil active nature of hexazinone, the environment is a likely cause of variation. Certainly, hexazinone has demonstrated the ability to seriously injure willow and these injuries have been shown to be persistent.

With the exception of one cut-surface application of 2,4-D amine, no trial work was found which qualified for entry in the data base. *Salix scouleriana* was studied in Mueggler and Lyon's (1966) long-term phenoxy herbicide trial. They found 41 of 60 treated plants to be alive 6 years after treatment. Dead crown kill on willow sprayed in June, August, and September averaged about 90% in 1961; 5 years later, the proportion of dead crown still averaged more than 50%. Persistent damage of such a degree is harmful to forage production.

[12] Newhouse and Geisler, 1986.

- *Sambucus* spp. — elderberries (SA SP)

  Glyphosate: 17 entries
  Liquid hexazinone: 4 entries
  Granular hexazinone: 2 entries
  2,4-D ester: 8 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 2 entries

Glyphosate caused severe to very severe damage to elderberry in several reports (Conard and Emmingham 1984b; Boyd *et al.* 1985; Newhouse and Geisler[13]). Although the researchers did not investigate the complete range of categories, there is substantial agreement that glyphosate is very damaging to elderberry. Kelpsas and Cleary (1981) found glyphosate to cause "light injury" after fall applications, and yet the Newhouse and Geisler observations in late summer and fall showed "severe-dead" injury ratings. It is difficult to say whether this contradiction is due to plant or environmental differences.

Elderberry displayed tolerance to hexazinone. Spring granular applications caused little damage, and a rate sensitivity was noted within the spring applications of liquid hexazinone. At the lesser rate, damage ranged between low and moderate; at the higher rate it ranged between moderate and severe.

- *Sorbus* spp. — Mountain ash (SO SP)

  Glyphosate: 5 entries
  Liquid hexazinone: 9 entries
  Granular hexazinone: 1 entry
  2,4-D ester: 5 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

The data for mountain ash were inconclusive, with only one or two findings under each category. Boyd *et al.* (1985) concluded that glyphosate caused "severe injury-kill" when applied from August to October, but most of their findings were based on applications of 3.35 kg ai/ha and, thus, were not relevant to this review. Late-summer applications in the Prince Rupert Forest Region had severe effects at rates of 1.6 and 2.0 kg ai/ha, yet an application at 1.5 kg ai/ha had "low" effect. The lower rate was a backpack application whereas the other two were aerial, and this may reflect methodology rather than rate.

Hexazinone spring applications show 0–90% injury for individual applications at < 2.2 kg ai/ha, and 70–90% at $>2.2<4.3$ kg ai/ha. Individual treatments showed no association between increased dosage (i.e., more intensive grid patterns) and increased damage.

- *Symphoricarpos* spp. — snowberries (SY SP)

  Glyphosate: 23 entries
  Liquid hexazinone: 4 entries
  Granular hexazinone: 1 entry
  2,4-D ester: 11 entries
  2,4-D amine: 0 entries
  Triclopyr ester: 0 entries

Glyphosate applications to snowberries resulted in severe to very severe injury in several entries. Table 1 in Appendix 1 shows the consistently high damage ratings. In their summary, Haeussler and Coates (1986a) reported that glyphosate resulted in "moderate control."

The 2,4-D ester data varied. Each category had three or fewer pieces of data, so results are inconclusive.

- *Vaccinium* spp.— blueberries/huckleberries

  Glyphosate: 11 entries
  Liquid hexazinone: 3 entries
  Granular hexazinone: 1 entry

[13] Newhouse and Geisler, 1986.

2,4-D ester: 6 entries
2,4-D amine: 0 entries
Triclopyr ester: 0 entries

Glyphosate caused moderate to severe damage to blueberries in the Boyd *et al.* (1985) trials and in the Prince Rupert area study.[14] Haeussler and Coates (1986a) reported that glyphosate caused "moderate control" when applied to *Vaccinium*.

The effects of 2,4-D ester were also moderate, ranging between 10 and 60% injury. There are too few entries to make any conclusions.

- *Viburnum edule* — highbush-cranberry (VI SP)

Glyphosate: 11 entries
Liquid hexazinone: 3 entries
Granular hexazinone: 1 entry
2,4-D ester: 6 entries
2,4-D amine: 0 entries
Triclopyr ester: 0 entries

Glyphosate caused moderate to severe damage when applied to highbushy-cranberry. The data analyzed were all from the Prince Rupert Forest Region.[15] Haeussler and Coates (1986a) concluded that glyphosate resulted in "good control."

In spring trials this forage species demonstrated tolerance to hexazinone. Individual applications during this season resulted in less than 39% damage for 13 entries. Applications at less than 2.2 kg ai/ha resulted in low damage. Finally, applications in the maximum range varied from 9 to 60%, and yet three of five entries were also in the light damage category. The majority of these trials were performed in the Burns Lake area (Expert Committee on Weeds 1985). Haeussler and Coates (1986a) reported hexazinone to have "moderate control" of highbush-cranberry.

4.4 Sedges and Grasses

- *Carex* spp. — sedges (CA SP)

Glyphosate: 14 entries
Liquid hexazinone: 29 entries
Granular hexazinone: 3 entries
2,4-D ester: 0 entries
2,4-D amine: 0 entries
Triclopyr ester: 0 entries

Glyphosate severely or very severely damaged sedges in all the treatments except dormant applications. All the *Carex* trials were from the inland Northwest (Boyd *et al.* 1985), and there were no trials at a species level of identification. Only two trials had both year one and year two results. One found 100% damage in year one and 53% damage in year two; the other found 88% damage in year one and 50% damage in year two. These results suggest a healthy recovery, although there are other examples of severe year two results, from trials in which year two was the only measure recorded.

Liquid hexazinone was equally damaging, causing severe to fatal responses in all treatments except the dormant season.

- Grasses (GR SP)

Glyphosate: 9 entries
Liquid hexazinone: 17 entries
Granular hexazinone: 5 entries
2,4-D ester: 0 entries
2,4-D amine: 0 entries
Triclopyr ester: 0 entries

[14] Newhouse and Geisler, 1986.
[15] Newhouse and Geisler, 1986.

Unfortunately, little herbicide research divides grasses on the basis of species, nor annual or perennial habit. As a result, the following discussion is based on grasses in the most general sense. Given the specificity of wildlife preferences, this remains a serious information gap.

The effects of glyphosate on grasses reported were conflicting. The Prince Rupert area study[16] found glyphosate to cause severe damage when applied in the late summer, and low to no damage when applied in the fall (except for one late summer observation which found low damage). Boyd *et al.* (1985) also found that glyphosate caused severe to fatal injury throughout the growing season, and Kelpsas and Cleary (1981) found the same result for spring and fall applications. Conversely, however, the Expert Commitee on Weeds (1985) found glyphosate to have "poor control" of *Calamagrostis*. Furthermore, *Calamagrostis* has been reported to increase after glyphosate applications, and replicate trials are needed to determine recovery period (J. Pollack, B.C. Ministry of Forests, pers. comm., 1987). Rapid recovery may be responsible for the contradictory results. As well, the limited surface area of grasses and their variable forms likely cause efficacy variation for a leaf uptake herbicide such as glyphosate.

Hexazinone, a "root-uptake" herbicide, is highly damaging to grasses. There are indications that the efficacy of hexazinone is related to the depth of the organic layer. Such conditions may account for the light damage noted for granular hexazinone treatments. Another factor determining efficacy is soil moisture. Granular hexazinone treatments, conducted summer through fall when the weather may have been dry, were found to have little effect. Otherwise, the overwhelming evidence of the severe damage caused by hexazinone applied to grasses is substantial enough to be a major concern in important grazing habitats. Furthermore, severe damage has been found to persist into the second year, increasing the effect on wildlife or livestock.

Ashton and Crafts (1981) reported that 2,4-D ester is selective for broadleaf plants. Boyd *et al.* (1985) found it caused little or no injury to grasses for applications throughout the growing season.

[16] Newhouse and Geisler, 1986

5 DISCUSSION

The following discussion is organized by herbicide, to assist users in evaluating herbicide prescriptions in operational use (i.e., X chemical over Y area), rather than by forage species or wildlife species. Herbicide treatment evaluations require knowledge of both the chemical properties of the herbicide and of site-specific environmental conditions, such as wildlife use and their requirements. The following sections are not intended to replace that knowledge.

Determination of the effects of herbicides is linked to their behaviour in the environment. This report focused on the most readily understood aspect of chemical behaviour: plant uptake. The degree to which the plants receive the herbicide has been related to amount (i.e., rate), phenology (i.e., season of application), method of application, and individual plant characteristics (e.g., evergreen versus deciduous habit). For a complete understanding of potential habitat impacts it is necessary to determine the consequences of these chemicals both within the plant, and within the community after the plant has been injured or killed. There is little information available on how these chemicals may alter palatibility or nutritional quality, or on their long-term effect on the environment (i.e., through species shift and community structure changes). This is a serious information gap, which hinders the assessment of the impact of herbicides on wildlife.

5.1 Glyphosate

Glyphosate represents 71% of the herbicide used in British Columbia forests in 1985 (Humphreys 1985). In 1986 it was estimated to be 78%.[17] Clearly, glyphosate effects on wildlife are of primary interest.

Approximately 400 out of 1300 entries analyzed were glyphosate trials. Glyphosate is a broad spectrum, relatively non-selective herbicide. Indeed most of the species studied, with the exception of the evergreens, showed instances of severe damage. However, the degree and timing of severe results were varied. Because the chemical is foliar active, the degree of damage is related to the amount aborbed and subsequently translocated in the plant. These are a function of method of application, plant characteristics, and environmental conditions.

Data analysis showed conflicting results about season of application. Early foliar glyphosate applications are often assumed to be most damaging because this is the period of most active translocation. Alternatively, leaves at maximum growth have more surface and increased absorption capabilities. Data analyzed in this study support every possible permutation of these two theories. Some forage species, however, show distinct trends. Mallow ninebark, for instance, was undamaged by early treatments but severely damaged by fall treatments. Further research directed at particular seasonal phenological sensitivities is warranted for glyphosate.

Individual plants may also respond based on health, age, or other factors unrelated to species physiology. As well, plant vigour may determine ability to absorb and translocate chemicals. It has also been suggested that rates of application may have inverse results. According to Sutton (1978):

> . . . there is some evidence that lower concentrations of glyphosate may achieve a greater herbicidal effect than a higher concentration. If a translocatable herbicide (like glyphosate) is applied at a higher concentration it may kill tissues on contact before the herbicide is translocated to other tissues.

The effects of environmental conditions on glyphosate are numerous and difficult to isolate. Because of its dependency on leaf absorption, glyphosate may be removed by rain, and require dry weather to have maximal effectiveness. The Herbicide Handbook (1979) suggests that "Rainfall occurring within 6 hours may reduce effectiveness. Heavy rainfall within 2 hours may wash it off."

Plants shown to be particularly sensitive to glyphosate were: aspen, saskatoon, redstem ceanothus, ocean-spray, black twinberry, wild cherry, elderberry, snowberry, and sedges. Those demonstrating tolerance were some conifers, salal, and falsebox.

[17] Walmsley *et al.*, 1986.

5.2 Hexazinone

Hexazinone is new to British Columbia forestry, and is currently undergoing changes in its registration. The label on Velpar-L® (a trade name for liquid hexazinone) says it is "registered temporarily for the control of certain weeds in Christmas tree plantations and weed control in reforestation areas of less than 500 hectares, by broadcast ground application and undiluted spot treatments" (DuPont Velpar-L® label). In this review approximately 600 of 1300 entries were hexazinone, approximately 70 of which used the granular formulation.

Several species found to be sensitive to hexazinone were tolerant of glyphosate and 2,4-D. This difference is related to the soil active nature of hexazinone. Not only do plant species have different absorption capabilities, but, as well, hexazinone efficacy is a function of different environmental conditions, notably soil type and depth. Generally, the deeper the organic layer the less "effective" the treatment. For this reason, hexazinone treatments on coastal species are usually less effective than on their interior counterparts (J. Pollack, B.C. Ministry of Forests, pers. comm., 1987).

Such a soil active chemical deserves concern about "off-site movement" — that is, movement outside the intended target area. Off-site movement of hexazinone is being studied by Pierre Beaudry under FRDA Project 1.21, located on two sites in the Prince Rupert Forest Region. British Columbia Pesticide Permits (Pesticide Control Branch) currently restrict applications to before July 31, to ensure plant uptake before the wet fall or freeze-up, to restrict potential movement.

5.3 2,4-D Amine and 2,4-D Ester

The chemical 2,4-D is one of the oldest in use in British Columbia as a forestry herbicide. It is selective for broadleaved species over grasses (Ashton and Crafts 1981). Because of fish toxicity concerns, the ester formulation is generally not used in British Columbia in broadcast treatments. In the United States, though, it is used extensively in broadcast (ground and aerial) applications because the ester is more effective than the amine formulation. Of the approximately 300 of 1300 entries pertaining to 2,4-D, only 5 were 2,4-D amine. In British Columbia, however, of the 1700 L used by B.C. Ministry of Forests in 1985, only 5% was the ester formulation. Hack-and-squirt projects throughout the province use 2,4-D amine. Severe damage was reported in each of the five entries in the data base.

5.4 Triclopyr Ester

Triclopyr ester is a broad spectrum herbicide, used in broadleaved and woody plant control. In British Columbia, triclopyr ester has research status only. This review found only a few trials, most of which were in the United States. From their trials in the U.S. inland Northwest, Boyd *et al.* (1985) concluded that triclopyr ester was "particularly effective in control of root sprouting plant species and that dormant applications, using oil, were effective, west of the Cascades, against evergreen species."

5.5 Shortcomings and Potential Solutions

The practical applications of the review are severely limited because of a number of shortcomings:

1. Sixty percent of the data base analyzed originated in the United States inland Northwest.
2. Most of the data from British Columbia were obtained in the Prince Rupert Forest Region.
3. There was a lack of habitat-specific trials in British Columbia.
4. Few or no data were collected for several highly important forage species, including birches, dogwood, willows, salmonberry and grasses. Often, data were not available at a species level.
5. A large variety of research methodologies and measures were compared as though equal, when the intensities were quite different (e.g., "walk-through" observation versus highly scientific silvicultural trials; and, percent defoliation versus percent crown kill).

6. Only the initial (1–2 years) effect of the herbicide on plants was addressed. Very few data have been collected demonstrating longer term effects.

The primary purpose of this review was to catalogue the current data. Potential solutions to the information gaps are:

1. Further research must be conducted throughout British Columbia, in areas of high forestry/wildlife values where herbicide use may create conflicts.
2. Data collection should be done to a common standard to allow valid comparisons.
3. Data must be related to ecological units (habitat types).
4. Many highly important forage species (such as, willows, birches, dogwood and salmonberry) warrant further species-specific study.
5. Impacts such as duration of effects, loss of forage and resultant community structure changes should be considered in future trials.

Many of these research needs are now being addressed in the Extension, Demonstration, Research and Development Sub-Program to the Canada—British Columbia Forest Resource Development Agreement, 1985–1990.

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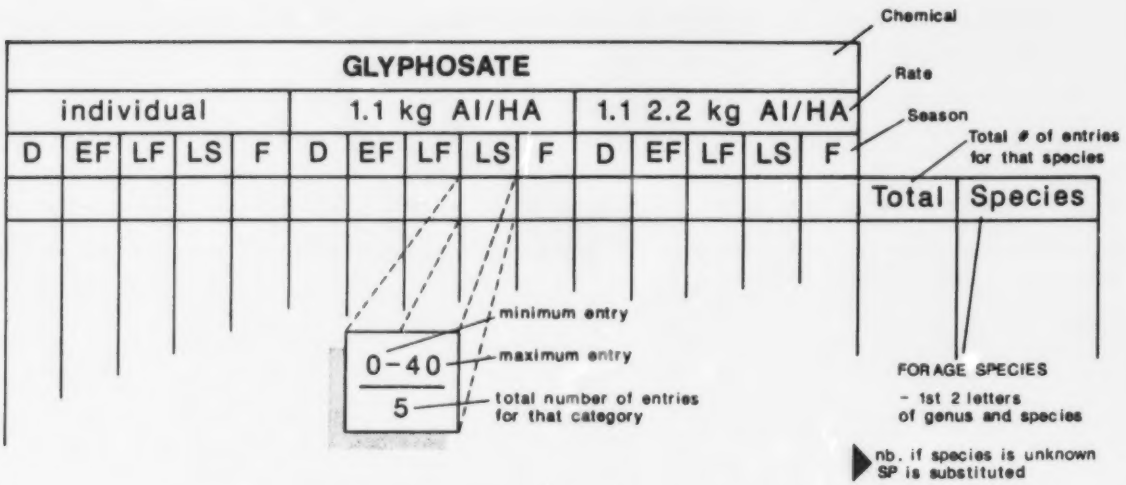
APPENDIX 1. Mathematical summaries

KEY TO TABLES



TABLES

TABLE 1. Glyphosate

GLYPHOSATE																	
INDIVIDUAL					≤1.1 KG AI/HA					>1.1 ≤2.2 KG AI/HA							
D	EF	LF	LS	F	D	EF	LF	LS	F	D	EF	LF	LS	F	TOTAL	SPECIES
							0-10 4				11-40 1	0-40 5	0-60 29	0 3	42	AB SP
														<25 1	1	AR ME
													60-100 3		3	BE SP
												100 1	0-100 12	25-90 2	15	PO SP
		60-90 1					0-10 1			0 1	11-100 5	0-60 5	0-10 11	0-24 5	29	PS ME
											100 1	20 1	0-90 3		5	SO SP
											0 1	10-60 2	0-10 5	0-25 2	10	TH PL
													0-90 8	25-60 1	9	TS E
														0-75 2	2	AC CI
							1-16 2	0 1			71 1	31-90 6	0-90 6	60-90 1	17	AC GL
								69-90 1			95-100 1	60-100 3	60-100 4	60-100 2	11	AM PL
						0 1									1	AR UN
							82-100 2				100 1	36-100 5	63-100 6	90-100 1	13	CE SA
						20 2	0 2					23-80 2		23-60 1	7	CE VE
													25-90 4	<25 4	8	CO BE
													25-60 2	60-90 1	3	CO SP
							12 1				11-18 2			<25 2	5	GA SH
							26-40 2				98 1	60-100 4	33-95 3	90-100 2	12	HO DI
													100 4	60-100 4	8	LO IN
							5 1	75-100 1				50-72 2	36-100 1		5	LO UT
						0-60 2									2	MA SP
								75-80 2				0 1			3	ME PE
							0 2					0 1	0-74 2		5	PA AM
						0-60 2	23 1				0 1	40-100 3	23-100 2	60-80 1	14	PH AB
							100 1				41 1	8-100 4	20-100 3		9	PH SP
							0-43 2	0 1			13-86 3	0-75 3	23-80 4	0-80 4	19	RI SP
							20 1				30-99 3	40-100 7	0-40 3	25-100 4	18	RO SP
										0 1		0-80 6	23-100 11	23-80 2	20	RU SP
							0-2 1			56-61 1	18-100 8	0-100 22	80-90 1		33	SAL SP
							63-94 1	78-100 2				90-100 6	75-81 4	75-100 4	17	SA SP
						80 2	0-2 1				33-100 5	36-100 7	25-100 8		23	SY SP
							16-43 3						23-100 5	25-80 3	11	VA SP
													25-80 4	0-100 4	8	VT ED
						40-100 3		100 1		0 1	50-100 6	90-100 1	60 1	40-100 1	14	CA SP
													24-90 5	0-24 4	9	GR SP

TABLE 2. Liquid hexazinone

LIQUID HEXAZINONE																	
INDIVIDUAL					≤2.2 KG AI/HA					>2.2 ≤4.3 KG AI/HA							
D	EF	LF	LS	F	D	EF	LF	LS	F	D	EF	LF	LS	F	TOTAL	SPECIES
					0-10 / 2	0 / 2					<25 / 1		0 / 1		6	AR SP
															0	AR HE
	45-90 / 20					2-90 / 13					0-100 / 7				40	BE SP
	15-100 / 28	85-98 / 5	90-98 / 4	80-100 / 13		0-100 / 13	65-65 / 1				48-100 / 10	86-95 / 2			74	PO SP
						0-24 / 2	0 / 2		0-10 / 1		40+ / 1	0-10 / 1			7	PS HE
	0-83 / 5					10-80 / 2					70-100 / 2				9	SO SP
	25-60 / 4					0-24 / 2					25-73 / 2				5	TH PL
	0-25 / 4					0 / 4							3 / 1		16	TS E
					24-27 / 2					3 / 1					17	AC CI
	0-60 / 7					0-24 / 6					0-90 / 3				0	AC GL
	25-90 / 9					0-29 / 5					80-100 / 3				0	AM AL
															0	AR UV
															0	CE SA
															0	CE VE
	0-99 / 10					0 / 3					25-60 / 2				15	CO SE
	60-90 / 6					0 / 1					25-60 / 2				7	CO SP
															0	GA SH
															0	HO DI
	0-90 / 3				31 / 2	0 / 1				62-77 / 2	75 / 1				9	LO IN
											90-95 / 2		0 / 1		3	LO UT
											0 / 1				1	MA SP
															0	MI FE
															0	PA MY
							60 / 1				40-70 / 2				3	PH MA
															0	PR SP
	0-25 / 6					0-23 / 5					8-100 / 5				16	RI SP
	20-100 / 19	83-100 / 14				0-100 / 4	80-90 / 1	30 / 1			40-100 / 8	45-100 / 2			49	RO SP
	0-80 / 27	48-80 / 4	0-60 / 3		12 / 1	100 / 18	78 / 1	100 / 1	20 / 1	69 / 1	20-100 / 8	80-95 / 2			65	RU SP
	25-100 / 28	43-90 / 6	20-100 / 4			1-90 / 12	50 / 1				0-100 / 10	58-83 / 2			63	SAL SP
						0-95 / 2					55-98 / 2				4	SA SP
						20-73 / 2		30 / 1			30 / 1				4	ST SP
											0-25 / 1	19-55 / 2			3	VA SP
	0-38 / 15					0-24 / 8						29-60 / 5			26	VI ED
				.	50-100 / 9	0-100 / 7		70 / 1	0-100 / 6		0-100 / 5	70 / 1			29	CA SP
	21-60 / 4	42-91 / 7		25-60 / 1		0 / 1	95-97 / 1				100 / 1	97-100 / 2			17	GR SP

TABLE 3. 2,4-D ester

2,4-D ESTER																	
INDIVIDUAL					≤2.5 KG AI/HA					>2.5 ≤5.1 KG AI/HA							
D	EF	LF	LS	F	D	EF	LF	LS	F	D	EF	LF	LS	F	TOTAL	SPECIES
						0-10 / 4		5-15 / 2		0-10 / 2	0-50 / 5	0 / 3	25-75 / 6		22	AB SP
													60-90 / 2		2	AR HE
															0	BE SP
							0-75 / 3					20-88 / 2		85 / 1	6	PO SP
						0-24 / 3		0-10 / 1		0-10 / 1	25-100 / 3	75 / 1	0-50 / 5		1	PS ME
											55 / 1	10 / 1	10-20 / 3		5	SO SP
						10 / 1		10 / 1		10 / 1	25-60 / 1				4	TH PL
						0-25 / 2	60-90 / 1	0-10 / 1		0-10 / 1					5	TS E
						<25 / 1						0-60 / 2	25-60 / 1		4	AC CI
						0-4 / 3		0-9 / 1			0-13 / 3		0-35 / 2		9	AC GL
						12-75 / 2	33-50 / 2	90-100 / 2			45-95 / 4	44-60 / 3	63-100 / 2		15	AM AL
												60 / 1			1	AR UV
						45-87 / 3		40-75 / 5			60-100 / 4	80 / 1	75-99 / 3		16	CE SA
						40 / 1	90 / 1	20-60 / 9		50 / 1	71 / 1	25-100 / 4	25-60 / 3	2-35 / 2	18	CE VE
															0	CO SE
															0	CO SP
						<25 / 2					<75 / 1	<25 / 1	0 / 1		5	GA SH
						0-80 / 4		80 / 1		60 / 1	0-67 / 3	20-90 / 2	0-60 / 4		15	HO DI
															0	LO IN
								20-58 / 2			0-58 / 1	0-58 / 1			4	LO UT
								0-60 / 2				0-20 / 2			4	MA SP
							34 / 1				34 / 1				2	ME PE
								0 / 4				0 / 2			6	PA NY
						0-30 / 1	0 / 1	0-20 / 3			0-62 / 2	10-60 / 2	0-24 / 3		12	PH MA
						6-13 / 2		30-50 / 4		50 / 1	40 / 1		29-24 / 1		9	PR SP
						0-100 / 8	18-100 / 9	4-66 / 6			0-100 / 4	10-100 / 8	0-70 / 4		39	RI SP
						15-21 / 1		0-63 / 8			1-52 / 2	30 / 1	0-76 / 4		16	RO SP
						45-62 / 2	39-70 / 2	0-94 / 4			0-60 / 2	72 / 1	25-58 / 3		14	RU SP
															0	SAL SP
								70-100 / 4		60 / 1		22-60 / 1	0-100 / 2		8	SA SP
						55-61 / 1		0-27 / 2	90-100 / 1		55-100	20 / 1	7-57 / 4		11	SY SP
								10-40 / 3			25-60 / 1	10 / 1	25-60 / 1		6	VA SP
															0	VI ED
															0	CA SP
															0	GR SP

TABLE 4. Granular hexazinone

GRANULAR HEXAZINONE																	
INDIVIDUAL					<2.2 KG AI/HA					>2.2 <4.3 KG AI/HA							
D	EF	LF	LS	F	D	EF	LF	LS	F	D	EF	LF	LS	F	TOTAL	SPECIES
								0-10/1					0-10/2		3	AB SP
															0	AR NE
									0/2					0/2	4	BE SP
															0	BO SP
							0-10/1		0-10/2		11-40/1				4	BS NE
								80/1							1	BD SP
															0	TN PL
															0	TS E
				2-24/2						8-24/2					4	AC CI
															0	AC GL
								0/1							1	AM AL
															0	AR LV
															0	CE SA
								30/1							1	CE VE
				<25/1						<25/1					2	CO SE
															0	CO SP
															0	GA SH
															0	MO DI
				2/1						30/1					2	LO IN
															0	LO UT
															0	MA SP
															0	NE FE
															0	PA MY
					60/1			70/1	30/1						3	PH SP
															0	PR SP
							0/1					0-70/2			3	RI SP
					90-100/2	50-75/2		70/1			90-100/2	25/1			8	RO SP
					95-100/2				10/1		97-100/2			7/1	6	RU SP
					2-98/3	12-49/2					3-95/3	0/1			9	SAL SP
					<25/1						<25/1				2	SA SP
					40/1										1	SY SP
														0/1	1	VA SP
						3-25/2							100/1		3	VI ED
					10-80/2			80/1							3	CA SP
						0-10/2			<25/1			0/1		75-80/1	5	GR SP

TABLE 5. 2,4-D amine

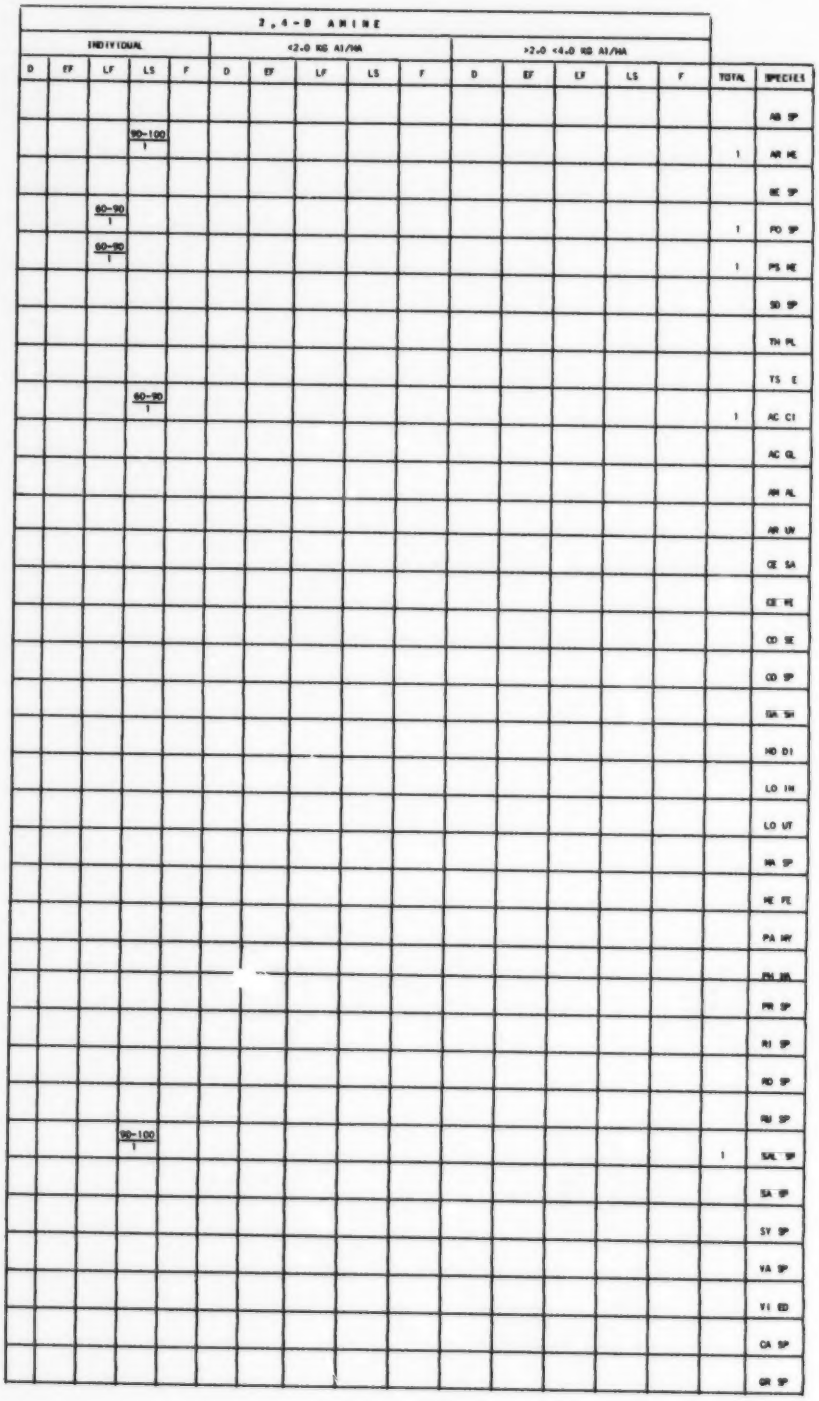


TABLE 6. Triclopyr ester

TRICLOPYR ESTER																	
INDIVIDUAL					<1.5 KG AI/HA					>1.5 <3.1 KG AI/HA						
D	EF	LF	LS	F	D	EF	LF	LS	F	D	EF	LF	LS	F	TOTAL	SPECIES
													0/1		1	AB SP
															0	AR HE
													0/1		1	BE SP
															0	FO SP
												<25/1		<25/1	2	PS ME
															0	SO SP
															0	TH PL
												<25/1		<25/1	2	TS E
												60-90/1		25-60/1	2	AC CI
															0	AC GL
															0	AH AL
															0	AR LV
						100/1		85-95/2			100/1	85/1	100/2		7	CE SA
					90/1	95/1				95/1			43-76/3		6	CE VE
															0	CO SE
															0	CO SP
						1/1					<25/3				4	GA SH
															0	HO DI
															0	LO IN
															0	LO UT
															0	MA SP
															0	ME FE
															0	PA MY
															0	PH MA
															0	PR SP
															0	RI SP
								0-75/3						43-97/3	6	RO SP
									0-12/1		30-83/2	98/1	98-100/2	12/1	7	RU SP
															0	SAL SP
											90-100/1		60-90/1		2	SA SP
															0	SY SP
															0	VA SP
															0	VI ED
															0	CA SP
															0	GR SP

APPENDIX 2. "Key Winter Forage Plants for B.C. Ungulates" (Blower 1982)

KEY WINTER FORAGE PLANTS FOR B.C. UNGULATES - 3RD DRAFT

SCIENTIFIC NAME	COMMON NAME	UNGULATE IMPORTANCE RANKING								
		coast deer	mule deer	white tail deer	mtn. goat	big-horn sheep	Roos-evelt elk	Rocky Mtn. elk	moose	caribou
Abies spp.	true firs (balsam)	2	2	3	2	3	2	2	2	2
Acer circinatum	vine maple	1	3	3	2	3	3	3	3	3
Acer glabrum	Rocky Mountain maple (Douglas maple)	2	1	2	1	2	2	1	2	3
Agropyron spp.	wheat grasses	3	2	2	1	1	3	1	3	2
Alectoria spp.	arboreal alectoria lichen	1	1	1	2	3	2	3	3	1
Amelanchier alnifolia	common Saskatoon	3	1	1	2	2	3	1	1	3
Arbutus menziesii	Pacific madrone (arbutus)	1	3	3	3	3	2	3	3	3
Arctostaphlos uva-ursi	kinnikinnick (bearberry)	3	1	2	2	2	3	3	3	3
Artemisia frigida	prairie sagebrush (pasture sage)	3	1	2	3	1	3	2	3	3
Artemisia tridentata	big sagebrush	3	2	3	3	2	3	2	3	3
Athyrium spp.	lady ferns	2	3	3	1	2	3	3	3	3
Berberis spp.	Oregon-grapes	2	2	2	2	2	2	2	3	3
Betula glandulosa	glandular birch (scrub birch)	3	3	3	3	3	3	2	1	2
Betula occidentalis	western birch (water birch)	3	2	3	3	3	3	2	1	3
Betula papyrifera	paper birch	3	2	3	2	3	3	2	1	2
Blechnum spicant	deer fern	2	3	3	3	3	1	3	3	3
Bromus spp.	brome grasses	3	2	3	3	2	3	1	3	3
Carex spp.	sedges	3	2	2	2	1	2	2	1	1
Ceanothus sanguineus	redstem ceanothus	1	1	2	2	3	3	2	2	3
Ceanothus velutinus	snowbush ceanothus	3	1	2	2	3	3	2	2	3
Cetraria spp.	arboreal cetraria lichen	2	2	3	2	3	2	3	3	1
Chrysothamnus nauseosus	common rabbitbrush	3	2	3	3	2	3	2	3	3
Cladonia spp.	cladonia lichens	3	3	3	3	2	3	2	3	1
Cornus sericea	red-osier dogwood	2	2	2	1	3	1	2	1	2
Corylus spp.	filberts (hazelnuts)	3	2	2	3	3	3	3	2	3
Festuca spp.	fescue grasses	3	3	3	1	1	3	1	3	2
Gaultheria shallon	salal	1	3	3	3	3	1	3	3	3
Holodiscus discolor	oceanspray	2	2	3	3	3	3	3	3	3
Juniperus communis	common juniper	3	2	3	2	3	3	2	3	3
Lonicera involucrata	twinberry honeysuckle	3	3	3	2	3	2	3	2	3
Lupinus spp.	lupines	3	2	2	3	2	3	2	3	3
Menziesia ferruginea	Pacific menziesia (false azalea)	2	3	3	3	3	2	3	3	3
Oplopanax horridus	devil's club	3	3	3	3	3	1	2	3	3
Paxistima myrsinites	Oregon boxwood	3	1	2	1	3	3	2	1	1
Penstemon spp.	penstemons	3	1	2	2	3	3	3	3	3
Philadelphus lewisii	mock orange	3	2	2	3	3	3	2	3	3
Physocarpus spp.	ninebark	2	3	3	3	3	2	3	3	3
Populus tremuloides	trembling aspen	3	2	2	3	3	3	2	2	3
Populus balsamifera	black cottonwood/balsam poplar	3	3	2	2	2	1	3	2	3
Prunus spp.	wild cherries	2	2	3	3	3	3	1	2	3
Pseudotsuga mensiesia	Douglas-fir	2	2	2	2	3	2	2	3	3
Poa spp.	blue grasses	3	3	2	2	1	3	2	3	3
Purshia tridentata	antelopebrush (bitterbrush)	3	2	2	3	3	3	1	2	3
Rhamnus purshianus	cascara	1	3	3	3	3	2	2	3	3
Rhus glabra	smooth sumac	3	1	2	3	2	3	3	3	3
Ribes spp.	currants/gooseberries	2	3	3	3	3	2	3	3	3
Rosa spp.	roses	2	2	2	3	3	2	2	3	3
Rubus pedatus	five-leaved creeping raspberry	2	3	2	3	3	2	3	3	2
Rubus spectabilis	salmonberry	2	3	3	3	3	3	3	3	3
Rubus ursinus	Pacific trailing blackberry	1	3	3	3	3	2	3	3	3
*Salix spp.	willows	2	2	2	1	3	2	2	1	2
Sambucus spp.	elderberries	2	3	3	3	3	1	2	3	3
Sorbus spp.	mountain-ashes	3	3	3	3	3	2	3	1	2
Symphoricarpus spp.	snowberries	3	3	3	3	3	3	2	3	3
Taxus brevifolia	western yew	2	3	3	3	3	2	3	2	3
Thuja plicata	western red cedar	1	3	2	3	3	2	3	2	3
Tsuga heterophylla	western hemlock	2	3	3	3	3	1	3	3	3
Vaccinium spp.	huckleberries/blueberries	1	3	3	3	3	2	2	2	3
Viburnum edule	highbush cranberry	3	3	3	2	3	2	3	2	3
Koeleria macrantha	prairie koeleria (junegrass)	3	2	3	2	2	3	3	3	3

*A wide range in palatability exists within the willows, varying from very high to low. "Upland willows", as a general group (eg. Bebb's willow, Scouler's willow), are mainly highly palatable.

Ranking Code: 1 - high importance
2 - moderate importance
3 - low importance

Vascular Plant Names Reference: TAYLOR R.L. AND B. MACBRYDE, 1977.

Main Information Sources: FISH AND WILDLIFE BRANCH - Regional Wildl. personnel corresp. 1972 + 1979.
TERRESTRIAL STUDIES BRANCH - B.C. Land Inventory data 1972 + 1976.
B.C. FOREST SERVICE - Research Branch corresp. 1979 + 1981.
FOOD HABITS OF WILDLIFE in B.C. - J. Singleton, June 1976.
Dan Blower, Terrestrial Studies Branch, Ministry of Environment, January 1982.

APPENDIX 3. Season descriptions (after Boyd *et al.* 1985)

Dormant or budbreak — Late winter or early spring at beginning of spring flush of growth. Buds on conifers are swelling or bursting, or new leaves are unfolding.

Early foliar — Period of active growth; approximately three-fourths of new leaves on shrubs are full size. Period of maximum susceptibility to herbicides.

Late foliar — During midsummer, usually mid-July to early August, after cessation of growth on conifers and shrubs. All leaves are full size and hardened. New terminal buds are well developed on conifers.

Late summer — Usually late August to early September, long after cessation of spring flush of growth.

Fall — Late September to November, after leaf fall; conifers usually dormant.

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